Point Loma Reballast Stability Study

by

Michael A. Miner

A Project

submitted to

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An Abstract for the Project of

Point Loma Reballast Stability Tests
by
Michael A. Miner

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Charles K. Sollitt

Large scale model studies of the Point Loma sewer outfall (San Diego, California) were performed at the O. H. Hinsdale Wave Research Laboratory, Oregon State University, in order to determine the stability of a proposed armor mound structure. Two scale models were constructed, one at 1:24 scale and one at 1:33.6. The 1:24 scale model was tested at Froude scaling of 1:24, 1:28.8, and 1:33.6 to examine median prototype armor stone diameters of 20 inches, 24 inches and 28 inches. The 1:33.6 scale model was tested only at the 1:33.6 Froude scaling. Both monochromatic and random wave conditions were modeled at prototype periods between 12 and 20 seconds. The outfall pipe outside diameter was 128 inches, prototype. Experimental data were measured with five resistive type wave gauges and two acoustic current meters. Test runs were also video recorded from two underwater and one above water location. Test conditions are presented in tabular form. Hydrodynamic properties are shown in non-dimensional graphs and are compared to one theoretical model. Surveys were taken of the mound structure at scale changes and showed the greatest armor loss to be at the mound shoulders. The final stable stone size as determined by these tests and video monitoring is a 28 inch prototype stone. The greatest measured horizontal velocities in a test series (up to 19 ft/sec, prototype) usually resulted in some armor rock motion unless the prototype wave period was greater than 18 seconds. The 28 inch diameter stone remained stable for monochromatic prototype wave heights of 75 feet or less.

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Table of Contents

List of Figures

List of Figures

List of Figures

List of Tables

List of Notation

Symbol	Definition
γ	specific weight of liquid
$\gamma_{concrete}$	specific weight of concrete, 150 lbs/ft^3
γ_d	ratio of material density in model relative to material density in prototype
γ_p	peak enhancement factor in JONSWAP Spectrum
$\gamma_{(FRESH\ WATER)}$	specific weight of fresh water, 62.4 lbs/ft^3
$\gamma_{(SEA\ WATER)}$	specific weight of sea water, 64.0 lbs/ft^3
γ_s	specific weight of sediment grain or armor stone
λ	scale ratio
π	pi
ρ	liquid density
ρ_s	stone density
τ_0	shear stress exerted by fluid flow on boundary material
τ_m	critical shear stress on sediment grain to cause incipient motion
υ	kinematic viscosity of liquid
ω	wave angular frequency ($2\pi/T$)
ζ_b	linear wave theory horizontal particle motion amplitude
$\zeta_b\ (\perp)$	the component of horizontal particle motion amplitude perpendicular to armor structure
a	acceleration
A	Area
D_{90}	sediment particle size for which 90% of grains are finer as used in Stanton Diagram
D_{50}	median diameter of armor rock
E	energy
f	frequency
f_o	filter cut-off frequency
f	friction factor
F_r	Froude Number
F	force
g	acceleration due to gravity
h	water depth
H	waveheight
H_b	breaking waveheight
H_{mo}	zero moment wave height
$H_{1/3}$	significant waveheight
H_{rms}	root mean square waveheight
$I.D.$	inside diameter
k	wave number ($2\pi/L$)

List of Notation

k_e	equivalent particle size on seabed as used in Stanton Diagram
L	wavelength
l	characteristic length
m	subscript denoting model units
M	mass
$O.D.$	outside diameter
p	subscript denoting prototype units
P	power
Q	flow rate
R	Reynolds number
R_b	boundary Reynolds number as used in Stanton Diagram
R_*	critical Boundary Reynolds number from Shield's curve
S	spectral density function from JONSWAP equation
s	height above seabed as used in Stream Function Tables
t	time
T	wave period
T_p	period at spectral peak
τ_*	critical dimensionless shear stress parameter from Shield's curve
U_{max}	maximum horizontal velocity under a wave
$U_{max}(\perp)$	the component of maximum horizontal velocity perpendicular to armor structure
U	uniform horizontal velocity of fluid
U_*	shear velocity
V	characteristic velocity
Vol	volume
$W_{pvc(dry)}$	weight per foot of PVC model pipe when dry
$W_{pvc(full)}$	weight per foot of PVC model pipe when full of fresh water
$W_{pvc(displaced\ water)}$	buoyant weight per foot of PVC model pipe
$W_{pvc\ model}$	total weight per foot of submerged PVC model pipe
$W_{p(dry)}$	weight per foot of prototype concrete pipe when dry
$W_{p(full)}$	weight per foot of prototype concrete pipe when full of fresh water
$W_{p(displaced\ water)}$	buoyant weight per foot of prototype concrete pipe
$W_{prototype}$	total weight per foot of submerged prototype pipe
$W_{PVC\_MODEL(MIN)}$	minimum total model weight required for PVC pipe
$W_{MODEL(MIN)}$	total weight per foot for PVC model pipe and added ballast required for proper Froude scaling
$W_{total\ ballast}$	total weight per foot of submerged rebar ballast
$W_{alum(dry)}$	weight per foot of aluminum model pipe when dry

List of Notation

$W_{alum(full)}$	weight per foot of aluminum model pipe when full of fresh water
$W_{alum(displaced\ water)}$	buoyant weight per foot of aluminum model pipe
$W_{alum\ model}$	total weight per foot of submerged aluminum model pipe
$W_{alum\_MODEL(MIN)}$	total weight per foot for aluminum model pipe and added ballast required for proper Froude scaling
X	horizontal distance corresponding to the longitudinal dimension of the two dimensional wave channel as referenced in Table 4.1 for instrumentation locations
Y	horizontal distance corresponding to the cross-channel direction of the two dimensional wave channel as referenced in Table 4.1 for instrumentation locations
Z	vertical distance referenced to the top of the false bottom slabs to a given point in the two dimensional wave channel as referenced in Table 4.1 for instrumentation locations
z	cartesian coordinate for vertical measurement; $z = 0$ at the still water level, $z < 0$ below the still water level, and $z = -h$ at the bottom

Conversion Factors, Non-SI to SI (Metric) Units of Measurement

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
miles (US Statute)	1.609347	kilometers
inches	2.54	centimeters
pounds (weight)	0.4535924	kilograms
pounds (weight) per cubic foot	16.01846	kilograms per cubic meter

POINT LOMA REBALLAST STABILITY STUDY

1.0 Introduction

1.1 Background

The Point Loma Sewage Treatment Plant Outfall services the City of San Diego, California. An additional sewage outfall will soon be in operation approximately 10 miles south-southeast of Point Loma, that being the South Bay International Wastewater Treatment Plant Outfall. The locations of both the existing Point Loma outfall and the future South Bay Outfall are shown in Figure 1.1.

The Point Loma site experienced an outfall rupture between 35 ft. and 50 ft. depth in February 1992. It was hypothesized that air entrainment within the outfall coupled with wave induced forces could have caused the rupture. Hydraulic testing at Oregon State University (OSU) was performed in February and March 1992 to test this theory (Ruggerio, 1993). Both the original condition and a proposed design were tested as is shown in Figure 1.2. An additional 12,500 ft. of outfall was added to the Pt. Loma system in late 1992, increasing the distance to the effluent discharge from 2.1 miles offshore to 4.5 miles.

South Bay Outfall is unique in that the outfall is being built in a lined tunnel beneath the seabed and only the diffuser will be exposed to the environment of wave induced forces. The tunnel will terminate at approximately 3.8 miles offshore at a mean water depth of 90 feet. Hydraulic testing at OSU was conducted to determine the better of two armor stone configurations (Freeman, 1994). The two diffuser cross sections tested in the wave channel are shown in Figure 1.3.

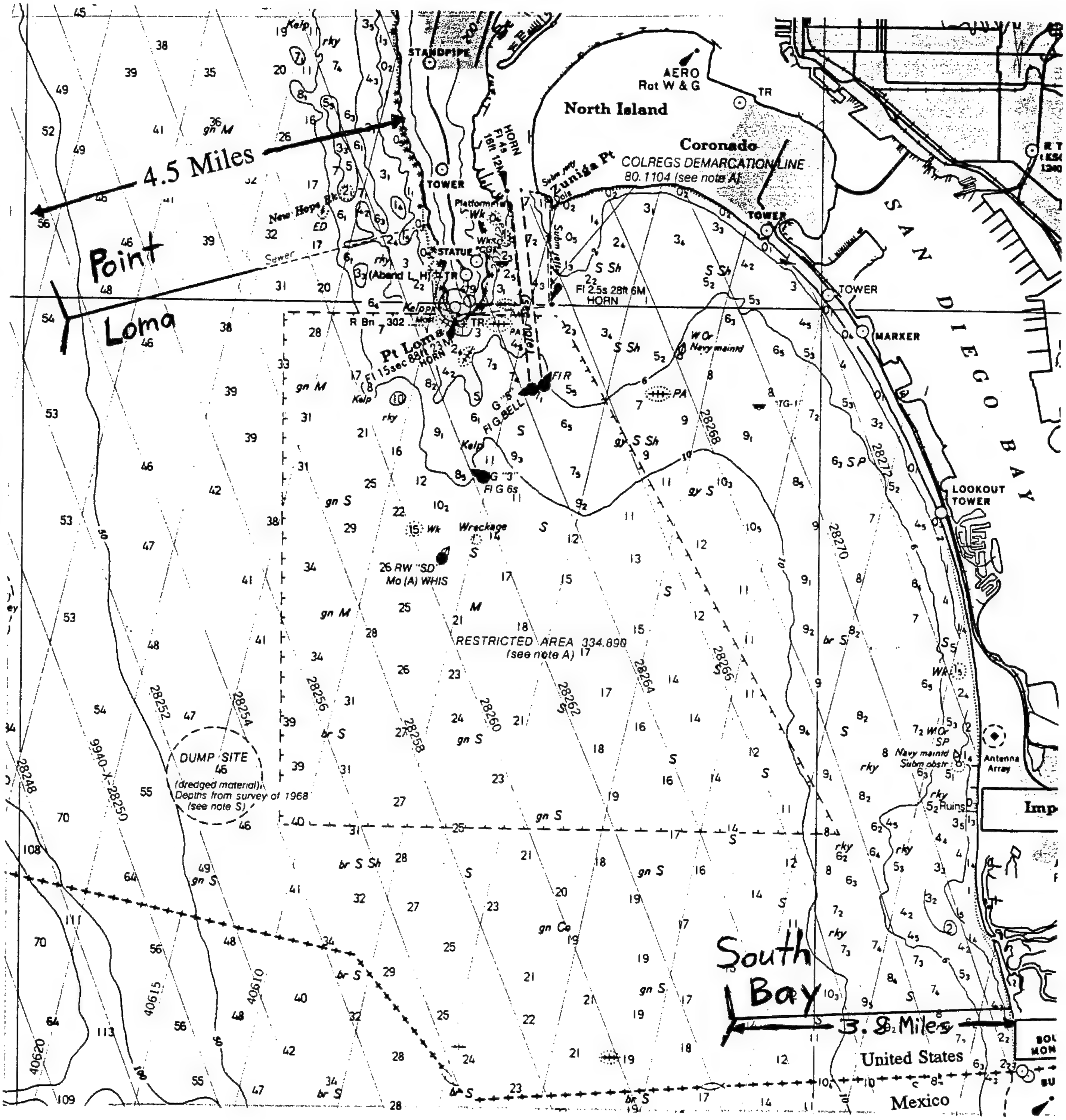

Figure 1.1 Location of Point Loma Outfall and South Bay Outfall

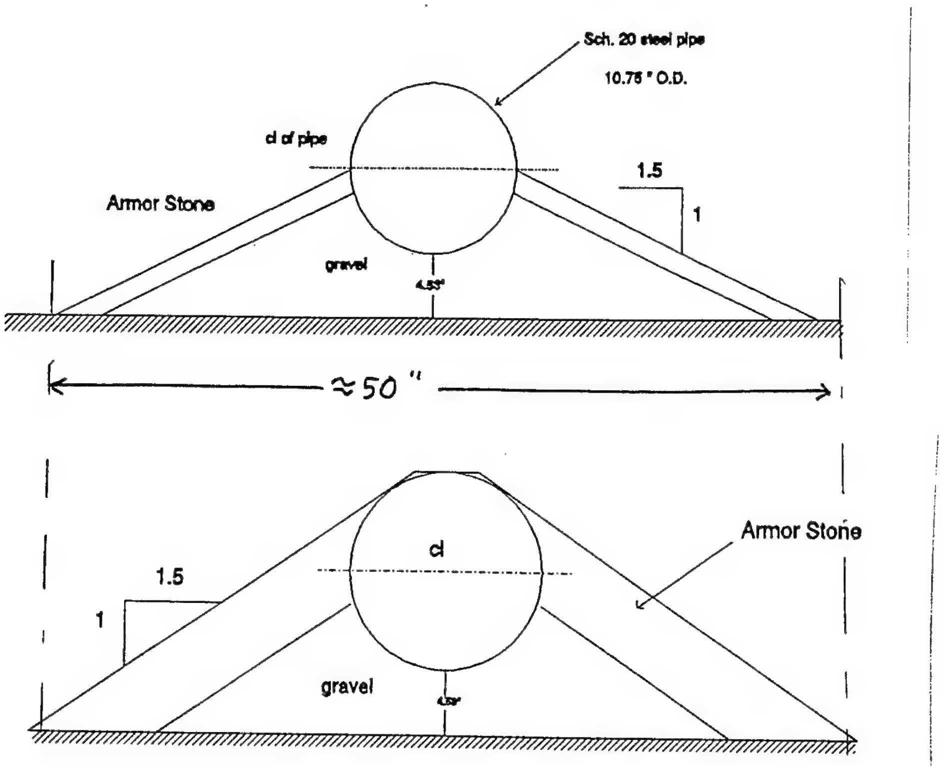

Figure 1.2 Pt. Loma Model Cross Sections Tested in February 1992 (After Ruggerio, 1993)

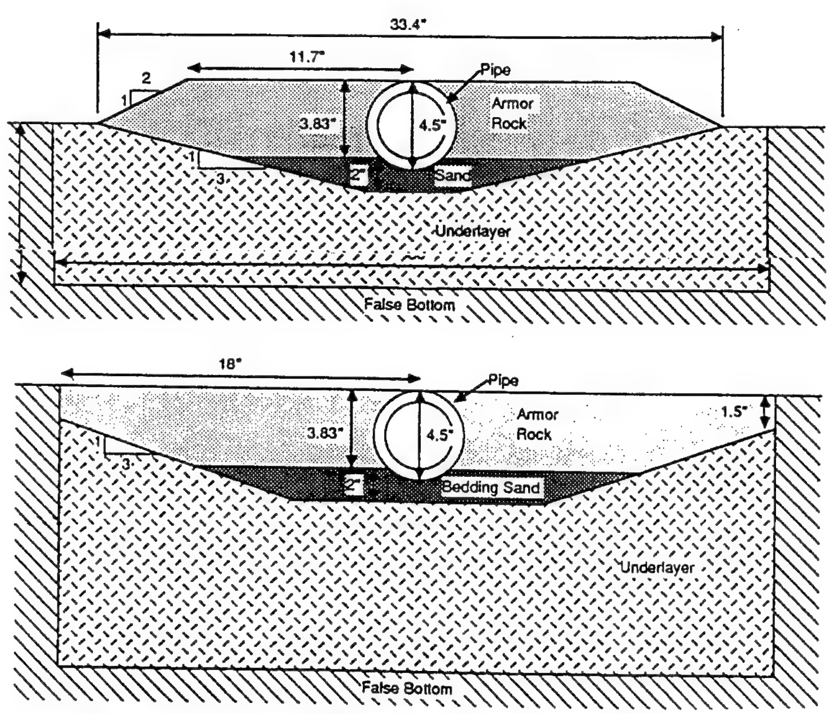

Figure 1.3 South Bay Diffuser Cross Sections Tested in 1994(After Freeman, 1994)

Underwater surveys have revealed that Pt. Loma Outfall is in need of additional ballast stone between the mean sea level depths of 60 to 175 feet. This portion of the outfall is located upon the steepest portion of the ocean floor profile as can be seen in Figure 1.4. The existing ballast material reaches the springline of the pipe in some areas, other sections have lost enough ballast material that so that the pipe is unsupported for short spans. A re-rocking effort must be performed in order to ensure this portion of outfall is protected against extreme hydrodynamic conditions which can generate wave heights of 80 feet in the vicinity of the outfall.

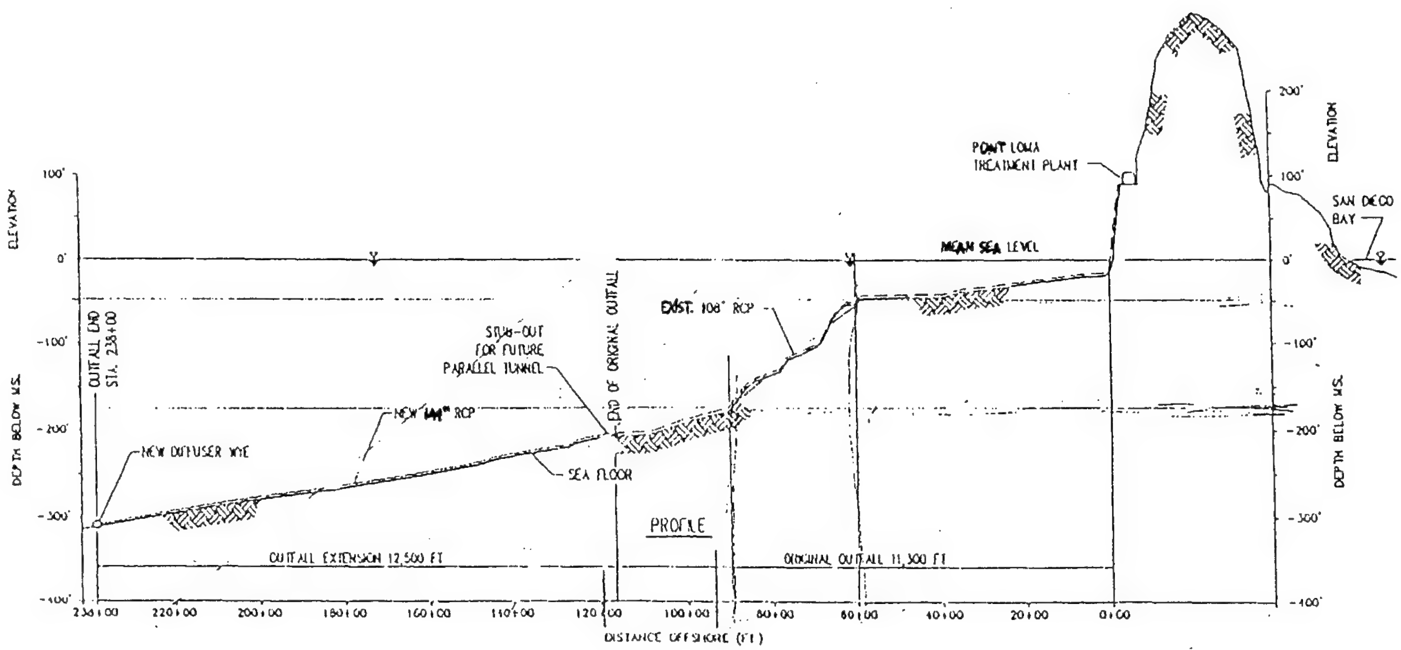

Figure 1.4 Point Loma Outfall Profile With Vertical Exaggerated 20 Times Horizontal

A composite underwater structure, such as a rubble armor protected pipeline, must be analyzed by considering stability of pipe as well as stability of the stone. The Morison equation can be used to determine the wave forces on pipelines (see Grace 1978), but the composite materials of pipe, armor stone and underlying bedding rock make force calculations much more complex. The stability of rubble structures built near still water level such as breakwaters and jetties is fairly well understood and design guidance is well documented (Shore Protection Manual, 1984). For an underwater armor stone ballasted pipe no clear design guidance has been written, so designs must be quite conservative or they must employ creative approaches based on past experience and physical model studies.

Most designs are subjected to hydraulic testing to confirm design effectiveness while minimizing construction cost. Parsons Engineering Science, Incorporated contracted with Oregon State University to perform model tests examining the stability of the Point Loma reballasting design.

1.2 Scope

This report discusses the scale model testing of the Point Loma reballasting design. The tests were undertaken at the Oregon State University O.H. Hinsdale Wave Research Laboratory in the large two dimensional wave channel. A false bottom was constructed from 12 ft. square by 6 in. thick concrete panels to simulate the ocean floor profile under the outfall. Shoreward of the false bottom 60 ft. depth the slabs were placed on a 1:12 slope to induce wave breaking and reduce reflection as is appropriate to the natural beach at Point Loma.

Parson's Engineering Science, Incorporated provided an initial replacement armor rock design mix ranging from 12 to 24 in. with a median (D_{50}) of 20 in. A scale ratio of

1:24 was selected as it optimized the WRL facility size to the desired prototype wave heights. The model armor design distribution was obtained by sieving local quarry rock in the range of 1/2 to 1.0 in., and combining it in the appropriate proportions. The existing ballast rock was modeled with a uniform mixture of 1/8 to 1/4 in. gravel, simulating 3 to 6 in. prototype ballast. The 128 in. concrete reinforced outfall was modeled with a 5 in. PVC pipe (O.D. of 5.56 in.). Number 8 reinforcing steel was inserted into the model pipe to provide a submerged weight greater than the scaled prototype pipe. Ventilated end caps were placed on model pipe to allow pipe to fill while avoiding large surge flows induced by pipe-end pressure differentials.

Two design cross sections were provided by Parson's Engineering Science Incorporated shown in Figure 1.5. The initial design (A) places the existing ballast rock at the springline of the pipe, and the new replacement armor terminates at approximately 1 o'clock and 11 o'clock. The alternate design (A1) has the same ballast rock condition but the pipe is covered with a single layer of armor stone. The A1 design was only to be tested if the A design was severely damaged under design wave conditions.

Figure 1.6 shows the two pipe sections that were modeled in the tests. The shallower model was centered at station 67+15 at a prototype depth of 98.5 feet. The deeper section was centered at station 71+25 with a depth of 110.5 feet. The 35° angle between pipe model and channel wall was used as it simulates the direction of severe storm wave approach to the Pt. Loma Outfall. The two test sections were each 20 ft. long simulating a total length of 960 ft. prototype at the 1:24 scale ratio.

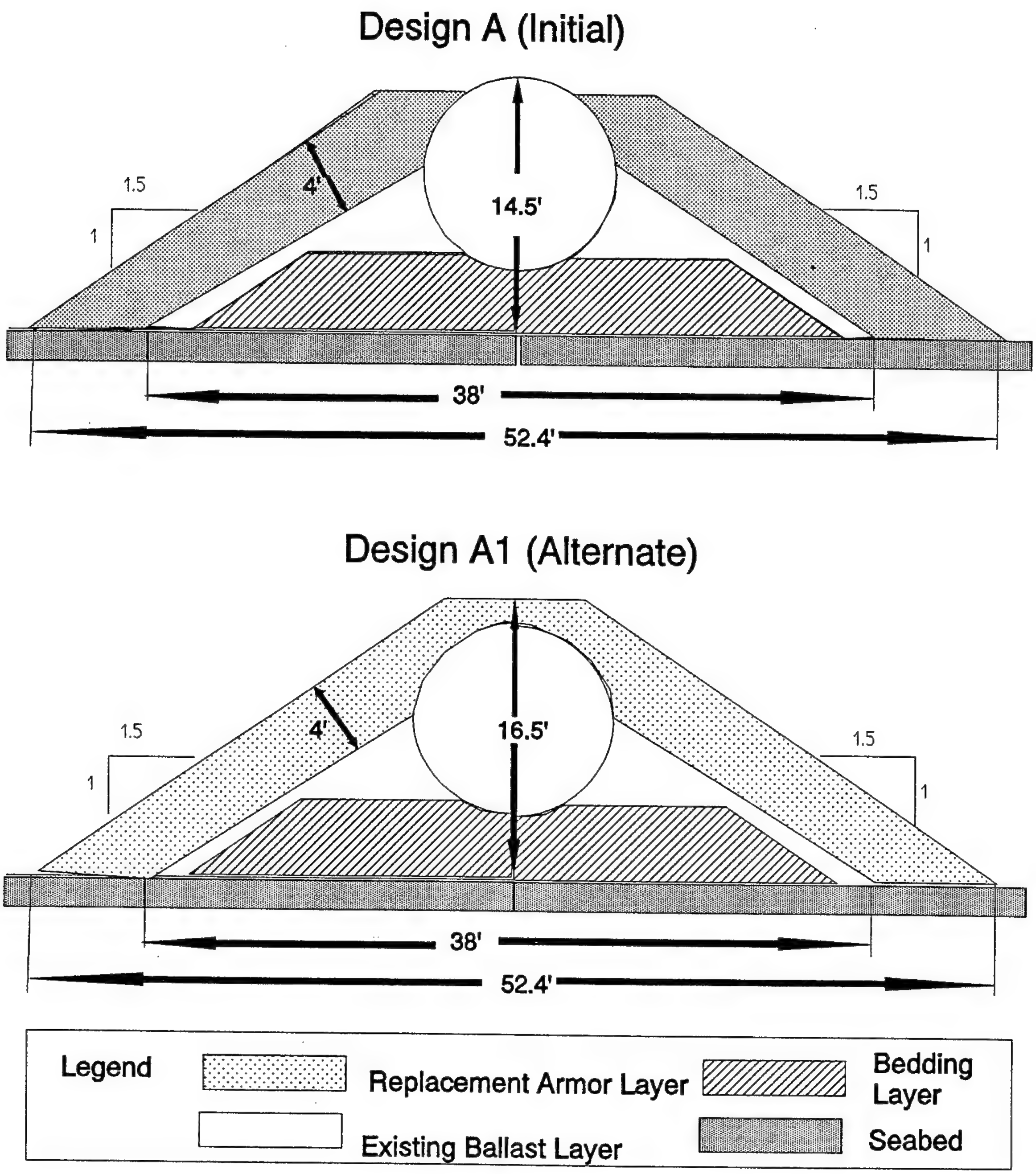

Figure 1.5 Initial and Alternate Cross Section for Pt. Loma Reballasting Study

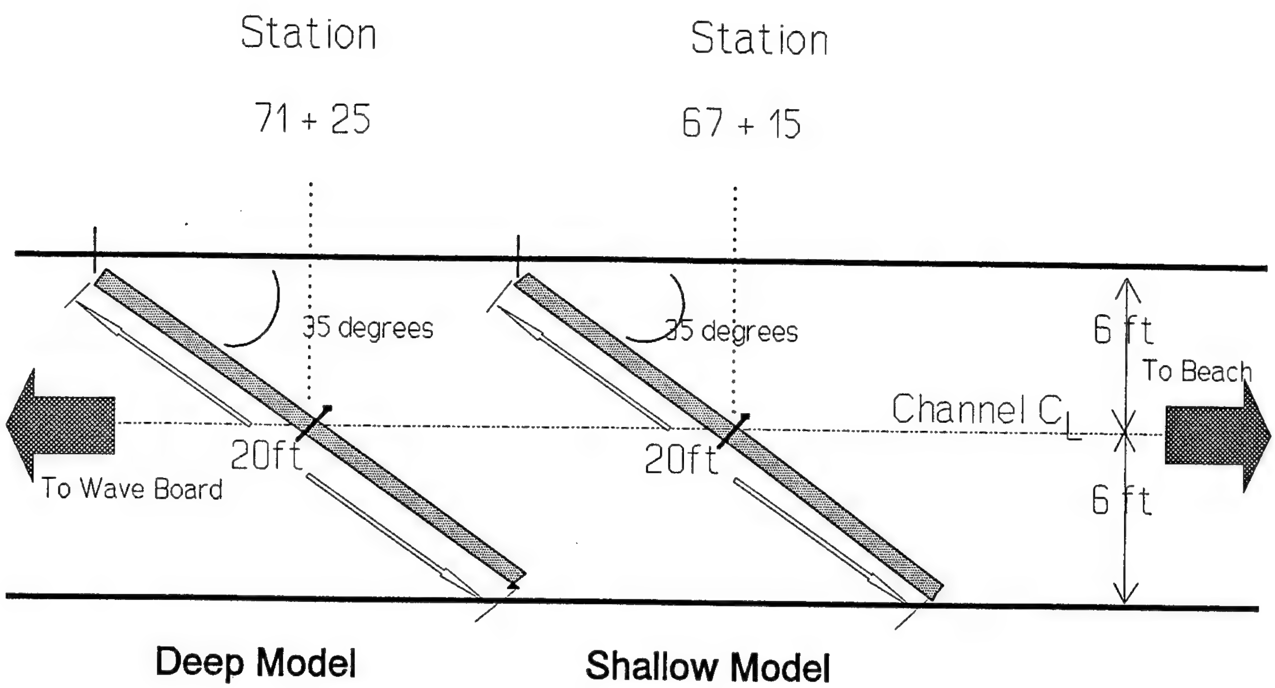

Figure 1.6 Plan View of Wave Channel in Area of Deep and Shallow Models

The initial test series of the A design was conducted at a 1:24 scale ratio, where D_{50} was equal to 20 in. The armor was unstable for wave heights greater than 60 ft. The scale ratio was changed to 1:28.8. Changing the scale ratio while using the same size model rock makes the apparent rock size larger. This is illustrated with the following example. The depth over station 67+15 is 98.5 feet prototype, so at the 1:24 scale ratio the model depth is $\frac{98.5ft}{24}$ or 4.1ft. When using 1:28.8 scale ratio, prototype depth remains constant so model depth must change to $\frac{98.5ft}{28.8}$

or 3.4 ft. Changing the scale ratio from 1:24 to 1:28.8 also changes the apparent prototype rock size; instead of the 1.0 in. model rock equaling 24 in. prototype, it is equivalent to 28.8 in.

Testing at the 1:28.8 scale ratio indicated the armor was unstable near the design wave conditions so the scale ratio was increased to 1:33.6. Armor rock was significantly more stable at the design wave conditions and a revised mound design was decided upon rather than testing the A1 (complete burial) design shown in Figure 1.5. The revised design (B) is shown as Figure 1.7 and it was built at a 1:33.6 scale ratio and replaced the 1:24 scale shallow model. A four inch aluminum pipe served as the model outfall with the same armor and ballast stone from the A design used in the B design. The 20 ft. model pipe simulated 672 ft. of the prototype, from approximately station 70+51 to station 63+79.

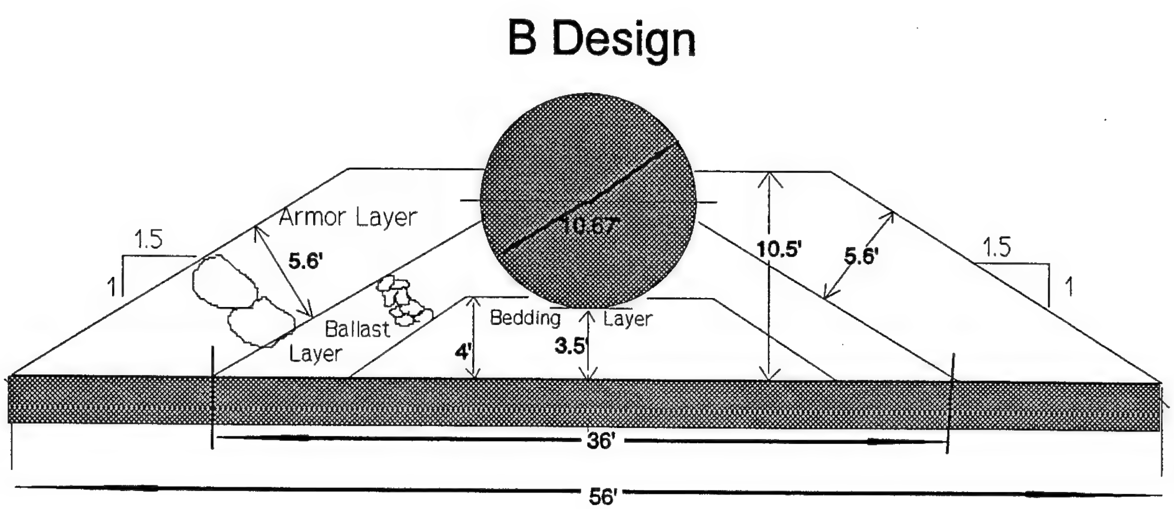

Figure 1.7 Cross Section of Revised Armor Mound (B) Design

The model was subjected to monochromatic and random waves with prototype periods of 12, 14, 16, 18, and 20 seconds. For random waves, the periods correspond to spectral peak periods. Each monochromatic wave test had a duration of 200 seconds while the random tests were 600 seconds. The testing procedure subjected the model outfall to a full range of wave heights at each scale ratio until significant rock motion was observed.

Wave conditions and rock stability were observed during the test runs. Five resistive type wave gauges measured the wave profile, and two acoustic velocity sensors measured water velocity above the pipe. Rock stability was observed through underwater video cameras. Quantitative surveys of the model pipe and armor mound cross-section were conducted at specific times corresponding to significant changes in the test conditions. The wave data and stability observations establish the stable rock size for Point Loma reballasting design.

Included in this report is a quantitative summary of the hydrodynamic conditions of each test run. Data collected during diver surveys is presented in terms of model profile changes. Results of experiments are given in tabular form for both model and prototype.

2.0 Method of Analysis

2.1 Stability Analysis

The purpose of the Point Loma reballast design tests was to determine the armor rock size that would be stable under the design wave conditions. Parson's Engineering Science, Incorporated provided a prototype design wave height H=83.16 feet and T=14 seconds. The greatest wave induced velocities associated with the design wave are at the shallowest section of the outfall being studied. In this study Station 67+15, with a depth of 98.5 feet below mean sea level, is the location where the rearmoring effort is to begin and the location where extreme design wave kinematics are utilized.

An analysis of stable stone size is briefly described by two methods. Both methods use the Shield's curve and empirically derived friction factors. The first method utilizes friction factors that were developed by Kamphuis (1975) for mean sediment grain sizes varying from 0.5mm to 40mm (0.02 in. to 1.57 in.). The second method obtains friction factors by boundary layer equations for turbulent rough flow through pipes.

The Shield's curve was developed for steady flow conditions rather than for oscillating flow, but numerous experiments have shown that data from oscillatory flows fit the Shield's curve quite well (Sleath, 1984). Consider a sediment grain or armor stone (with median diameter of D_{50}) surrounded by other similar armor stones lying on the bottom of a wide channel. The channel is carrying a uniform flow of liquid that has a uniform horizontal velocity of U. Let the liquid's density and kinematic viscosity be designated by ρ and υ, respectively. The stone density is ρ_s. The specific weight of the armor stone is γ_s, and the specific weight of the liquid is γ.

The shear stress exerted by the flow on the boundary material (the stones) is τ_0. Let the armor stone stress just before incipient motion occurs be τ_m. Combining the above variables non-dimensionally, two dimensionless parameters are plotted forming the Shield's curve. Figure 2.1 exhibits the shear stress parameter

$$\tau_* = \frac{\tau_o}{(\gamma_s - \gamma)D_{50}} = \frac{\tau_o}{(\rho_s - \rho)gD_{50}} , \tag{2.1}$$

and a boundary Reynolds number

$$R_* = \frac{U}{\upsilon} D_{50} = \frac{\sqrt{\tau_o / \rho}}{\upsilon}(D_{50}). \tag{2.2}$$

For the fully turbulent flow regime, as can be expected in most natural cases such as large waves over a pipeline, the boundary Reynolds number of $R_* \geq 500$, yields a shear stress parameter, τ_* , of 0.06.

The fluid flow boundary shear stress, τ_0 , can be determined from the equation

$$\tau_0 = \frac{f}{4}\left(\rho \frac{U^2}{2}\right), \tag{2.3}$$

where f is the friction factor and U is the steady, uniform flow speed. Solving for U under the wave crest in oscillatory flow yields U_{max} which can be computed by linear wave theory and the friction factor is determined empirically.

By using the Shield's curve and setting the flow shear stress (τ_0) from equation 2.3 equal to the stress on the armor stone at incipient motion (τ_m) and solving for the case where $\tau_* = 0.06$ the following equation

$$D_{50} = \frac{\frac{f}{4}\left(\frac{\rho U_{max}{}^2}{2}\right)}{(\gamma_s - \gamma)(0.06)} \tag{2.4}$$

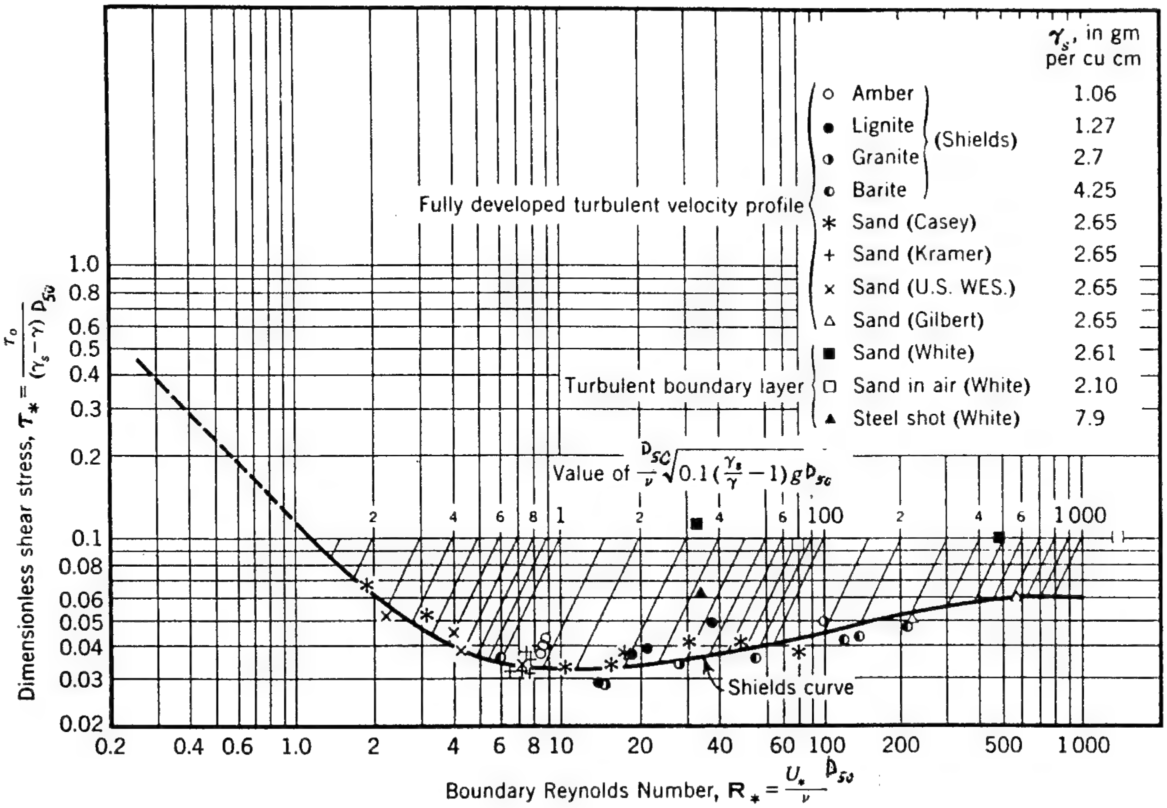

Figure 2.1 Shield's Curve (after Vanoni, 1975)

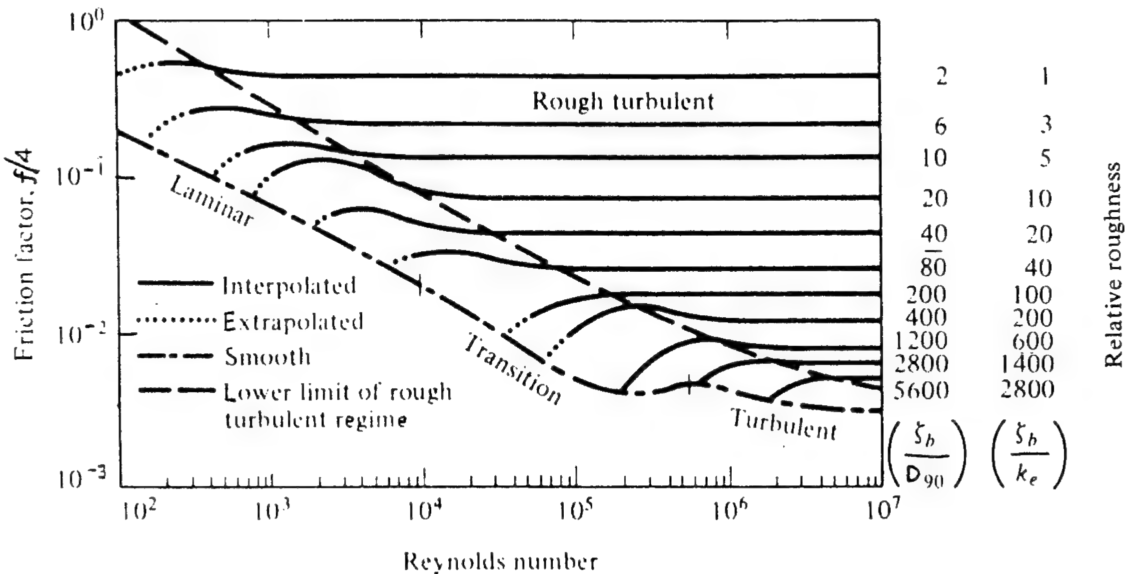

Figure 2.2 Stanton Diagram for Friction Factor Under Waves as a Function of Reynold's Number (defined as $R_b = (U\zeta_b)/\nu$) and Relative Roughness (after Kamphuis 1975)

is used to iteratively solve for a stable stone size.

Using the expression for a shoaling wave breaking depth ,

$$\frac{\text{depth of breaking}}{\text{breaking wave height}} = \frac{d_b}{H_b} = 1.28 \tag{2.5}$$

and the outfall depth at Station 67+15 of 98.5 feet, the design wave shallow water breaking height is 77 feet. The following sample calculations use H= 80 feet rather than the calculated depth limited breaking height for the outfall local depth of 98.5 feet as follows:

$$U_{max} = \frac{\omega H}{2\sinh(kh)} = \frac{2\pi / 14\sec{}^* 80ft}{2\sinh[(2\pi / 707ft) * 98.5ft]} \approx 18ft/\sec. \tag{2.6}$$

Figure 2.2 is a diagram developed by Kamphuis (1975) which shows $\frac{f}{4}$ from equation 2.3 as a function of Boundary Reynolds parameter and relative roughness. For rough turbulent flow the $\frac{f}{4}$ value is not dependent on Boundary Reynolds parameter and remains constant for a given roughness. The term ζ_b is the amplitude of the water particle motion at the bottom (h = - z) in the absence of a boundary layer. Equivalent particle size on the seabed is k_e , and D_{90} is the particle size for which 90% of the grains are finer. ζ_b is found from linear wave theory:

$$\zeta_b = -\frac{H}{2}\frac{\cosh k(h+z)}{\sinh(kh)} = \frac{80ft}{2}\frac{1}{\sinh[(2\pi / 707ft) * 98.5ft]} \approx 40ft. \tag{2.7}$$

As can be seen in Figure 2.3, the design wave approach angle is assumed to be at 55° from outfall. By using the U_{max} and ζ_b as determined above, large values for the stable stone size are obtained by the two stability methods shown below. Calculations for stable stone size are also shown by using the normal component of velocity to the armor stone shown in Figure 2.3.

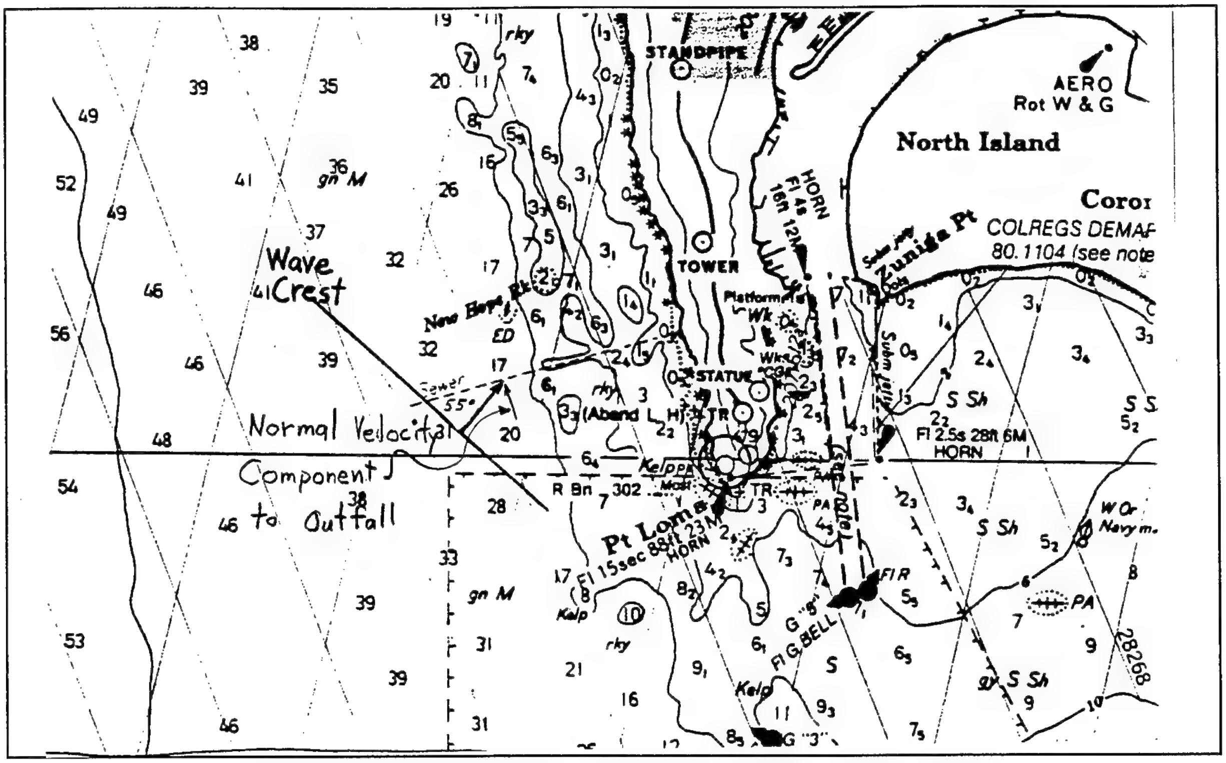

Figure 2.3 Design Wave Approach Angle at Point Loma

2.1.1 Stability Analysis - Method One

The friction factor shown on Figure 2.2 is obtained by selecting some value for D_{90} and calculating the ratio of ζ_b / D_{90}. Inserting the resulting value of $\frac{f}{4}$ into equation (2.4) and solving for d_s refines the stone diameter. Although Kamphuis defined the curves based on D_{90}, for these approximate stability calculations it is assumed the difference between D_{50} and D_{90} can be ignored.

Specific gravity of armor stone is assumed to be 2.65, yielding a γ_s =165lbs/ft. Using the velocity and water particle amplitude calculated for the design wave, the final iteration is shown below for D_{90}=24.9ft.

Specific gravity of armor stone is assumed to be 2.65, yielding a γ_s =165lbs/ft^3. Using the velocity and water particle amplitude calculated for the design wave, the final iteration is shown below for D_{90}=24.9ft.

$$D_{50} = \frac{\frac{f}{4}\left(\frac{\rho U_{\max}{}^{2}}{2}\right)}{(\gamma_s - \gamma)(0.06)} = \frac{0.47\left(\frac{64lbs/ft^3}{32.2ft/s^2}\frac{(18ft/s)^2}{2}\right)}{(165lbs/ft^3 - 64lbs/ft^3)(0.06)} = 24.9ft\,. \tag{2.8}$$

However, a much smaller value results when using the normal component of U_{max} and ζ_b as is shown below. From Figure 2.3 it is seen the normal components of U_{max} and ζ_b are

$$U_{max}(\perp) = \cos 55°(U_{max}) = 0.574\ (18\ \text{ft/sec}) = 10.3\ \text{ft/sec, and} \tag{2.9}$$

$$\zeta_b\ (\perp) = \cos 55°(\zeta_b) = 0.574\ (40\ \text{ft}) = 23.0\ \text{ft.} \tag{2.10}$$

By using a D_{90} of 2.36ft and substituting the value of (2.10) into the relative roughness ratio of Figure 2.2 , a friction factor over four $\left(\frac{f}{4}\right)$ value of 0.136 is obtained and,

$$D_{50} = \frac{\frac{f}{4}\left(\frac{\rho[U_{\max}(\perp)]^{2}}{2}\right)}{(\gamma_s - \gamma)(0.06)} = \frac{0.136\left(\frac{64lbs/ft^3}{32.2ft/s^2}\frac{(10.3ft/s)^2}{2}\right)}{(165lbs/ft^3 - 64lbs/ft^3)(0.06)} = 2.36ft\,. \tag{2.11}$$

Kamphuis lab work glued armor stones in a natural pattern to the shear plate in the experimental set-up so using the normal component of velocity and the normal component of water particle displacement in the above equations does not seem appropriate. However the resulting stable stone size calculated with maximum velocities and water particle displacements is unreasonably high. Considering that Kamphuis utilized an oscillating water tunnel with water particle displacements of 0.5m to 3m (1.64 ft to 9.84 ft) and periods of 2.5 seconds to 15 seconds to develop Figure 2.2 it may be inappropriate to use the resulting friction factors on a prototype

with more than four times the water particle displacement. Additionally, the largest experimental sediment used by Kamphuis was a D_{90} = 46mm (1.81 in.) and for both sample calculations the boundary Reynolds number exceeds the range of Figure 2.2 being in one case $7x10^7$ and in the other $2x10^7$.

2.1.2 Stability Analysis - Method Two

Grace (1978) proposes the use of a friction factor obtained through boundary value equations based on rough turbulent pipe flow,

$$\frac{1}{\sqrt{f}} = 2\log_{10}\frac{h}{D_{50}} + 2.11 \tag{2.12}$$

where h = the depth of the fluid flow and D_{50} = median stone diameter. Solving equation (2.12) for f and inserting into equation (2.4) results in

$$D_{50} = \frac{\frac{1}{8}\left[2\log_{10}\frac{h}{D_{50}} + 2.11\right]^{-1/2} \rho U_{max}{}^{2}}{(\gamma_s - \gamma\ )(0.06)} \quad . \tag{2.13}$$

By using the value of U_{max}=18ft/sec the final iteration is

$$D_{50} = \frac{\frac{1}{8}\left[2\log_{10}\frac{98.5ft}{6.26ft} + 2.11\right]^{-1/2} \rho(18ft/s)^2}{(\gamma_s - \gamma)(0.06)} = 6.26ft\,, \tag{2.14}$$

and by using the normal component of velocity to the outfall ($U_{max}(\perp)$ = 10.3 ft/sec) the stable stone diameter becomes

$$D_{50} = \frac{\frac{1}{8}\left[2\log_{10}\frac{98.5ft}{1.84ft} + 2.11\right]^{-1/2} \rho(10.3ft/s)^2}{(\gamma_s - \gamma_l)(0.06)} = 1.84ft\,. \tag{2.15}$$

This method results in a more reasonable range of stone sizes. Comparing empirical friction factors to an outfall that will be many times higher than a single layer of armor is at best a rough approximation. The actual rock size distribution within the armor mound, the effect of structural porosity, and breaking wave conditions are not considered with this type of stability analysis. However, these sample calculations offer a starting point for model testing. This project modeled median armor diameters of 20, 24, and 28 inches. The closest predicted diameters were 22 inches and 28 inches, obtained using the normal component of U_{max} in both methods discussed above.

2.2 Non-Dimensional Analysis

Two forms of scaling are commonly used to represent the relationship between model and prototype. In modeling the gravitational restoring force the Froude Number is used. Froude scaling employs the ratio of inertial to gravitational forces. Modeling the viscous forces is accomplished by use of the Reynolds Number. The Reynolds Number represents the ratio of inertial forces to viscous forces. Both gravitational and viscous forces are important in the design of underwater structures. It would be ideal for a model study to modify these two forces to an appropriate scale ratio, but the use of low viscosity fluids or centrifuges (which can achieve this result) are unnecessarily complicated and costly.

With large scale modeling it was observed by Sollitt and Debok,(1976) that scaling errors associated with viscosity become negligible. As long as a Reynolds number exceeding 2×10^5 is maintained in the model fluid flow, then viscous effects with errors less than 3% relative to prototype are realized when the same fluid is used throughout.

With larger scale modeling it is assumed water is incompressible and that surface tension is negligible. Having achieved Reynolds similarity via a large scale model, dynamic similitude is assured by maintaining equality of Froude number during scaling. Inertial forces per unit mass are scaled as convective accelerations which equal the product of velocity times the velocity gradient. This is the same as the velocity squared divided by the length scale. Gravitational forces per unit mass are simply scaled as the gravitational acceleration constant. The Froude number is expressed as the ratio of inertial force per unit mass divided by the gravitational force per unit mass,

$$F_r = \frac{(V^2 / l)}{g} = \frac{V^2}{gl} \ . \tag{2.16}$$

In equation 2.16, V = characteristic velocity, g = gravitational acceleration constant, and l = characteristic length. Therefore equation 2.16 can be written as

$$\left(\frac{V}{\sqrt{gl}}\right)_p = \left(\frac{V}{\sqrt{gl}}\right)_m \tag{2.17}$$

where the subscripts p and m stand for Prototype and Model, respectively.

Transposing equation 2.17 provides the ratio of model to prototype velocity as

$$\frac{V_m}{V_p} = \sqrt{\frac{l_m}{l_p}} = (\lambda)^{1/2} \tag{2.18}$$

where $\lambda = l_m / l_p$.

Time scales as the ratio of length to velocity or

$$\frac{t_m}{t_p} = \frac{l_m / V_m}{l_p / V_p} = \sqrt{\frac{l_m}{l_p}} = \lambda^{1/2} . \tag{2.19}$$

Acceleration scales as the ratio of velocity to time or

$$\frac{a_m}{a_p} = \frac{V_m / t_m}{V_p / t_p} = \frac{V_m / V_p}{t_m / t_p} = \frac{\lambda^{1/2}}{\lambda^{1/2}} = \lambda^0 = 1.0 \ . \tag{2.20}$$

Area scales as the square of the length ratio or

$$\frac{A_m}{A_p} = \frac{l_m^2}{l_p^2} = \lambda^2 \ . \tag{2.21}$$

Volume scales as the cube of the length ratio or

$$\frac{Vol_m}{Vol_p} = \frac{l_m^3}{l_p^3} = \lambda^3 \ . \tag{2.22}$$

Mass scales as the product of density times volume or

$$\frac{M_m}{M_p} = \frac{\rho_m Vol_m}{\rho_p Vol_p} = \frac{\rho_m}{\rho_p}\lambda^3 = \gamma_d \lambda^3 \tag{2.23}$$

where the quantity γ_d is the ratio of material density in the model relative to the material density in the prototype. Weight scales as the product of mass times gravity or

$$\frac{W_m}{W_p} = \frac{M_m g_m}{M_p g_p} = \gamma_d \lambda^3 \ . \tag{2.24}$$

Force scales according to Newton's Law as the product of mass times acceleration or

$$\frac{F_m}{F_p} = \frac{M_m a_m}{M_p a_p} = \gamma_d \lambda^3 (1.0) = \gamma_d \lambda^3 \ . \tag{2.25}$$

Energy scales as the product of the force times the distance (or characteristic length) as

$$\frac{E_m}{E_p} = \frac{F_m l_m}{F_p l_p} = \gamma_d \lambda^3 \lambda = \gamma_d \lambda^4 \ . \tag{2.26}$$

Power scales as the product of the force times velocity or

$$\frac{P_m}{P_p} = \frac{F_m V_m}{F_p V_p} = \gamma_d \lambda^{3} \lambda^{1/2} \gamma_d \lambda^{7/2} \quad . \tag{2.27}$$

Flow rate scales as volume per unit time or

$$\frac{Q_m}{Q_p} = \frac{Vol_m / t_m}{Vol_p / t_p} = \lambda^{3} \lambda^{-1/2} = \lambda^{5/2} \quad . \tag{2.28}$$

Pressure scales as force per unit area or

$$\frac{PRESSURE_m}{PRESSURE_p} = \frac{F_m / A_m}{F_p / A_p} = \gamma_d \lambda^{3} \lambda^{-2} = \gamma_d \lambda \quad . \tag{2.29}$$

The scale ratio used in building the model for the Pt. Loma Reballast Project was 1:24 and 1:33.6. The relationships between the model and prototype parameters are summarized in Table 2.1 for Froude Scaling at the given scale ratio.

Table 2.1 Froude Model Scaling Values

Property	Scaling	λ=1:24	λ=1:33.6
Length	λ	1:24	1:33.6
Area	λ^2	1:576	1:1129
Volume	λ^3	1:13,824	1:37,933
Time	$\lambda^{1/2}$	1:4.899	1:5.797
Velocity	$\lambda^{1/2}$	1:4.899	1:5.797
Acceleration	λ^0	1.0	1.0
Weight	$\gamma_d\lambda^3$	1: 13,824γ_d	1:37,933γ_d
Force	$\gamma_d\lambda^3$	1: 13,824γ_d	1:37,933γ_d
Energy	$\gamma_d\lambda^4$	1:331,776γ_d	1:1,274,551γ_d
Power	$\gamma_d\lambda^{7/2}$	1:67,723γ_d	1:219,881γ_d
Flow Rate	$\lambda^{5/2}$	1:2821.8	1:6544
Pressure	$\gamma_d\lambda$	1:24γ_d	1:33.6γ_d

3.0 Model Description

3.1 Test Facility

Model tests were performed at Oregon State University's O.H.Hinsdale Wave Research Laboratory. The laboratory two dimensional wave channel is shown in Figure 3.1. The channel is 342 feet long, 12 feet wide, and 15 feet deep, sloping to 18 feet deep at the hydraulically driven, hinged flap wave board. Sixty four channels of digital data collection and wave generator control are optically linked to a VAX server 3400 and two VAX 3100 stations. The wave generator is servo-hydraulically driven with direct digital controls. A 150 horsepower electric motor powers a 3000 psi, 76 gpm hydraulic pump which is the driving mechanism for the 8 inch diameter wave board actuator. The actuator ram has a stroke of $\pm$ 30 inches and is located 10 feet above channel bottom. The waveboard is dewatered on the back side and the hydrostatic pressure head is countered by a nitrogen gas spring applied to the actuator. The waveboard sides are sealed with plastic wiping seals which slide on stainless steel cladding epoxied to the channel walls.

The waveboard is controlled by two feedback loops, one for displacement control and one for board velocity. The displacement control senses waveboard position and applies a correction to minimize displacement errors relative to the input position signal. Velocity control senses the wave profile on the wave board face. Calculation of the linear wave solution for the waveboard transfer function allows the velocity to be corrected to generate the desired wave profile. The velocity feedback loop provides active absorption of reflected waves within the channel.

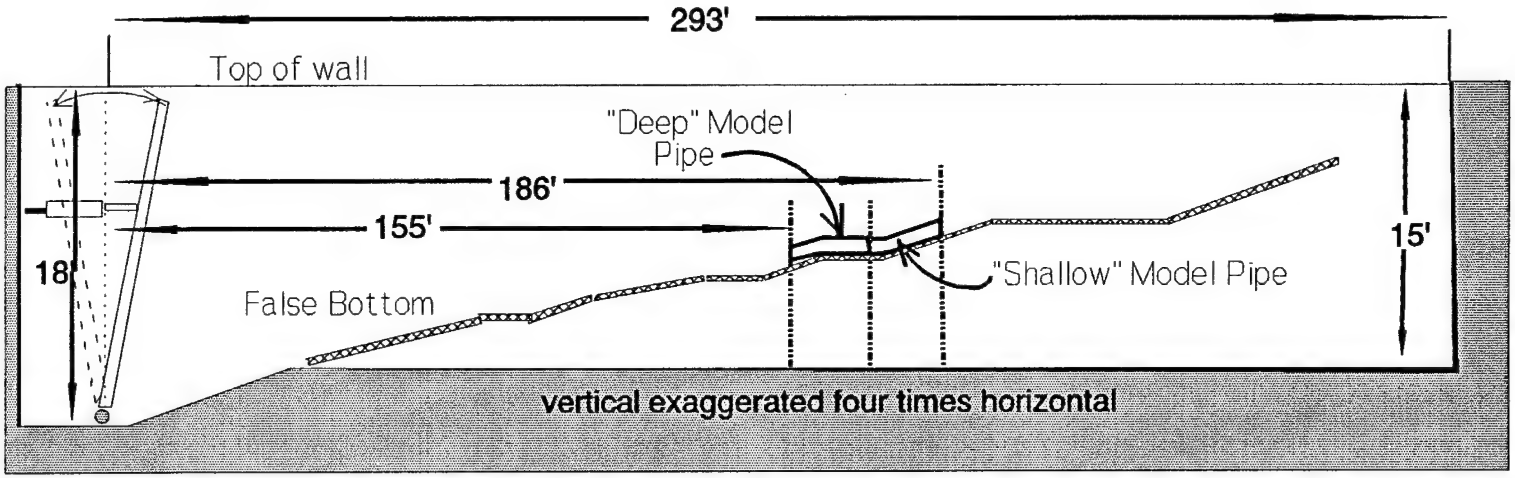

Figure 3.1 Schematic of O.H. Hinsdale Two-Dimensional Wave Channel Profile for Point Loma Stability Study Tests

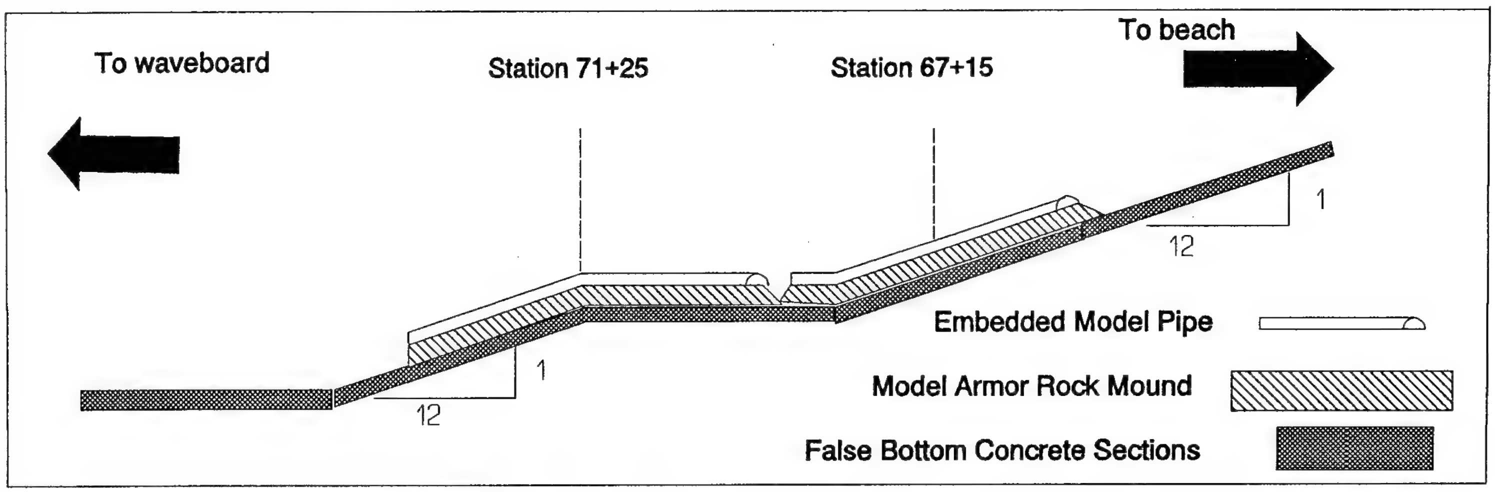

Figure 3.2. Wave Channel Profile Enlargement Near Model Section

3.2 Bottom Profile

The bottom profile shown in Figure 3.1 and amplified in Figure 3.2 was constructed using false bottom sections bolted to the channel walls. These six inch thick slabs can be placed at one foot increments and shimmed to six inch increments to yield bottom profile slopes of 1:24, 1:12, or zero. For this series of tests the bottom profile consisted of two 1:12 sloping sections, one flat section, one 1:12 sloping section, two 1:24 sloping sections, one flat section, and a 1:12 sloping section which shoaled the incident waves as they proceeded toward the model.

The bottom profile used for these tests closely follows the profile slope shown of Figure 3.3 which is a redrawn portion of "as-built" survey data on the Point Loma Outfall. The two portions of the model shown in Figure 3.4 were built across a sloping section of 1:12, a flat section, and another 1:12 sloping section corresponding to stations 72+00 to 66+00 in Figure 3.3. Approximately half of the deeper model is built on a 1:12 sloped panel and the other half is on a flat panel. About five feet of shallow model is on a flat panel and the remainder on a 1:12 sloped panel. Shoreward of the model, three flat sections followed by four 1:12 sloping sections induced wave breaking and minimized reflection, simulating the effect of the Point Loma shoreline. The model was placed in the channel with a 35° orientation from the east wall of wave channel to simulate the direction of large design waves as shown in Figure 3.4. The portions of outfall especially of interest in the testing were from station 67+15 (in prototype depth of 98.5 feet), to station 74+34 (at prototype depth of 118.5 feet) which scaled to be the center of the two model pipes.

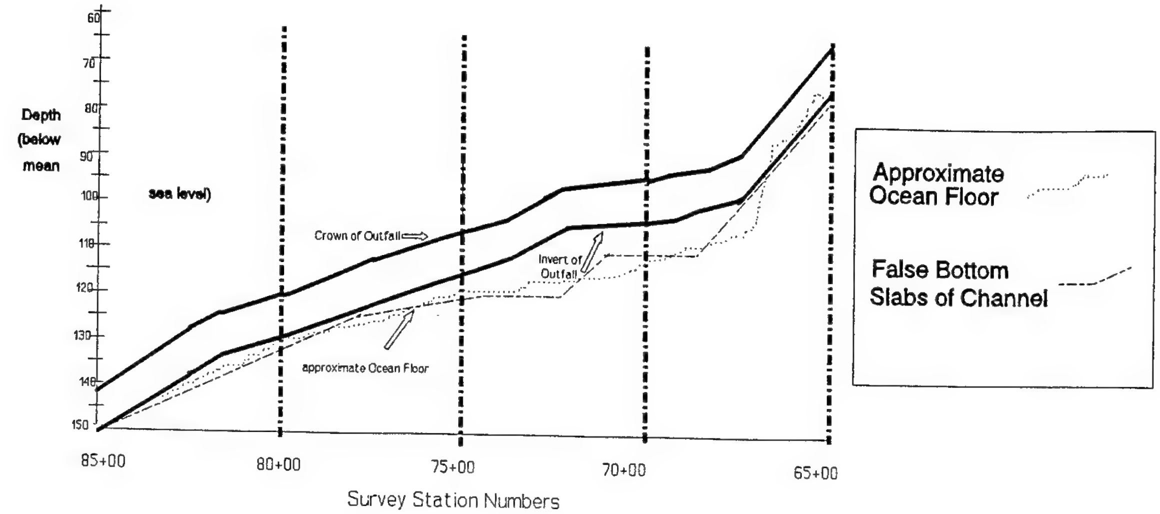

Figure 3.3 Profile of Existing Outfall With Wave Channel Bottom Superimposed

Figure 3.4 1:24 Scale Model Ready For Testing. Deep Model Upper Left, Shallow Model Lower Right

3.3 Geologic Materials

The reballast design requires two rock layers, an existing ballast stone layer covered by a courser armor stone layer. A third layer was used in the model, a finer aggregate than the ballast stone which acted as a graded filter between the concrete false bottom and the ballast stone.

The model used a commercial product, RMC Lonestar Coarse Aquarium Sand, as the under-ballast graded filter. This sand was purchased in 100 lb bags and was placed on wave channel false bottom prior to model pipe installation. The distribution of model graded filter material and corresponding prototype sizes (for 1:24 Scale model) are listed in Table 3.1 and shown graphically in Figure 3.5.

The intermediate layer of model rock was obtained by sieving local crushed quarry rock using a Gilson Test-Master Sieve producing fractions with divisions of 1/8 in., 3/16 in. and 1/4 in. Gradation of ballast layer was prepared by the following mix proportions: 50% of 1/8 in. - 3/16 in., 50% of 3/16 in. - 1/4 in. The batches of rock were washed and mixed in a concrete mixer for approximately 5 minutes as is shown in Figure 3.6. Sieve analysis of the resulting mixture are listed in Table 3.2 and shown graphically in Figure 3.7. This material simulates the existing ballast rock which is graded between 3 in. and 6 in.

Table 3.1
Graded Filter Material Size Distribution For 1:24 Scale Model

Cumulative % Passing	Sieve Size (US Standard)	Sieve Size (millimeters)	Prototype Size (inches)
99 ± 1	#4	4.75	4.49
70 ± 7	#6	3.35	3.17
10 ± 3	#8	2.36	2.23
2 ± 2	#12	1.70	1.61
1 ± 1	#16	1.18	1.12

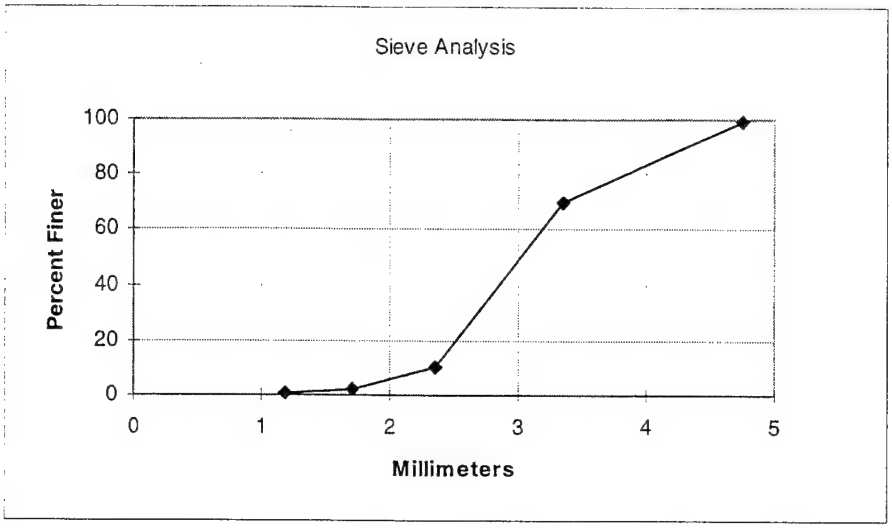

Figure 3.5
Graded Filter (Aquarium Sand) Size Distribution

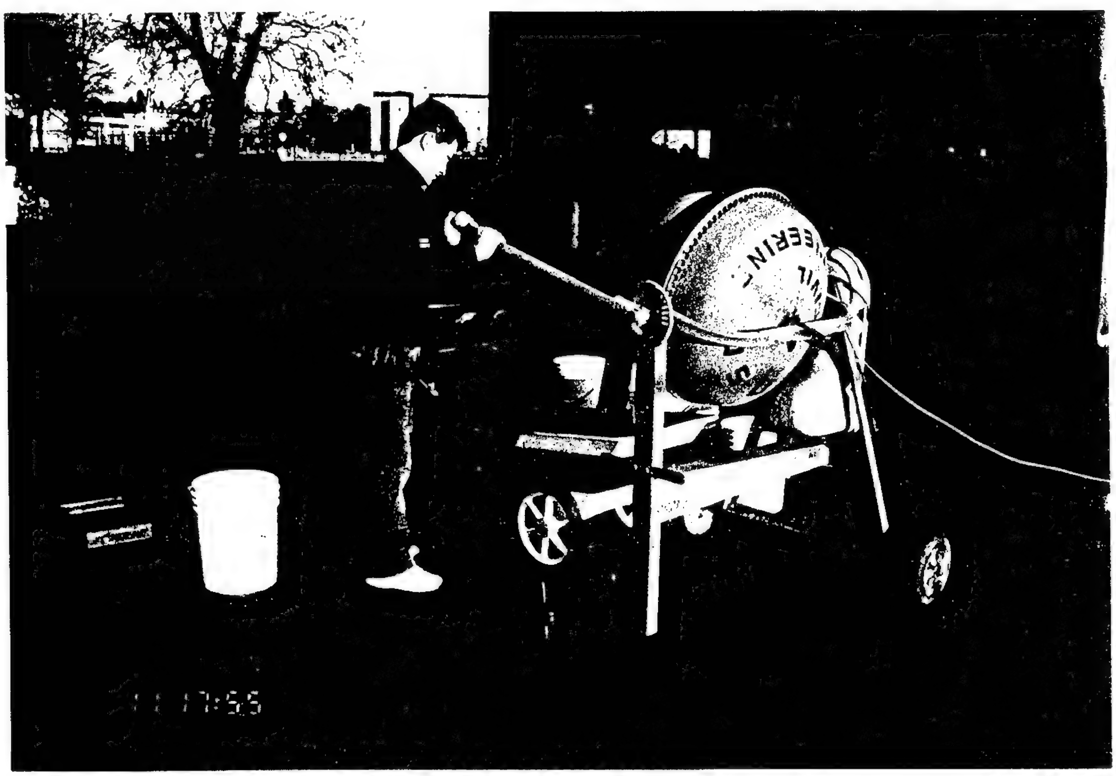

Figure 3.6 Mixing and Washing of Ballast Stone Prior to Building Model

Table 3.2
Ballast Stone Layer Material Size Distribution For 1:24 Scale Model

Cumulative % Passing	Sieve Size (inches)	Prototype size (inches)
100	1/4	6
50	3/16	4.5
0	1/8	3

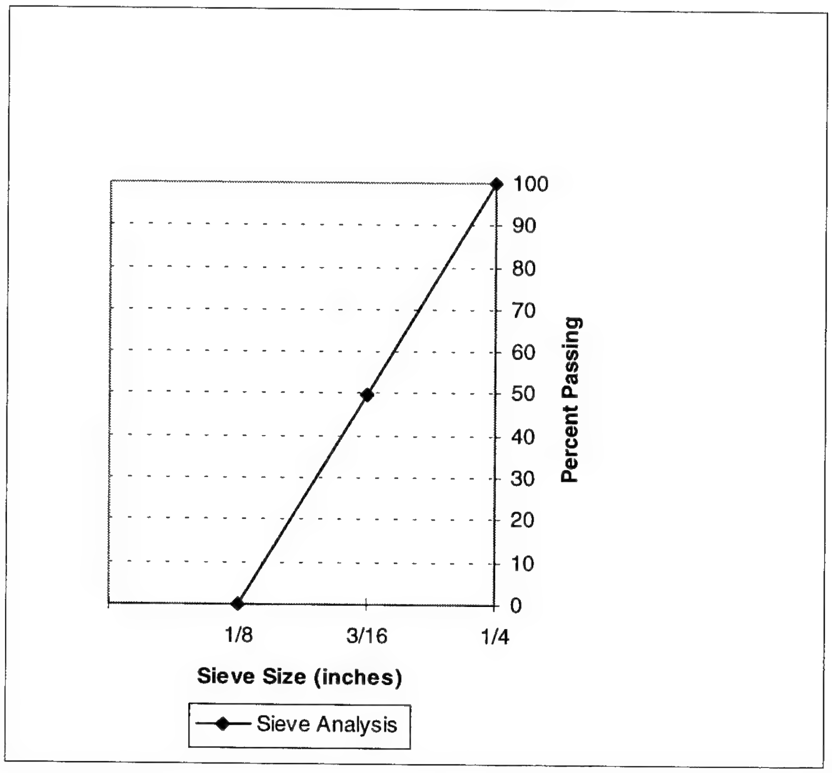

Figure 3.7
Ballast Stone Layer Size Distribution for 1:24 Scale

Armor rock for the model was sieved with the Gilson Test-Master and produced fractions with divisions of 1/2 in., 5/8 in., 3/4 in., 7/8 in., and 1 in. The specified armor layer gradation was prepared by the following mix proportions: 10% of 1/2 to 5/8 in., 15% of 5/8 to 3/4 in.,

3/4" to 7/8", and 30% of 7/8" to 1". The photograph in Figure 3.8 shows the four model armor stone stockpiles and weighing of rock prior to placing it into the concrete mixer. Each resulting 100 lb batch was washed and mixed for approximately 10 minutes in the concrete mixer. Sieve analysis of the mixture can be seen in Table 3.3 and Figure 3.9. Both prototype armor sizes are shown in Table 3.3 for the 1:24 Scale and the 1: 33.6 Scale.

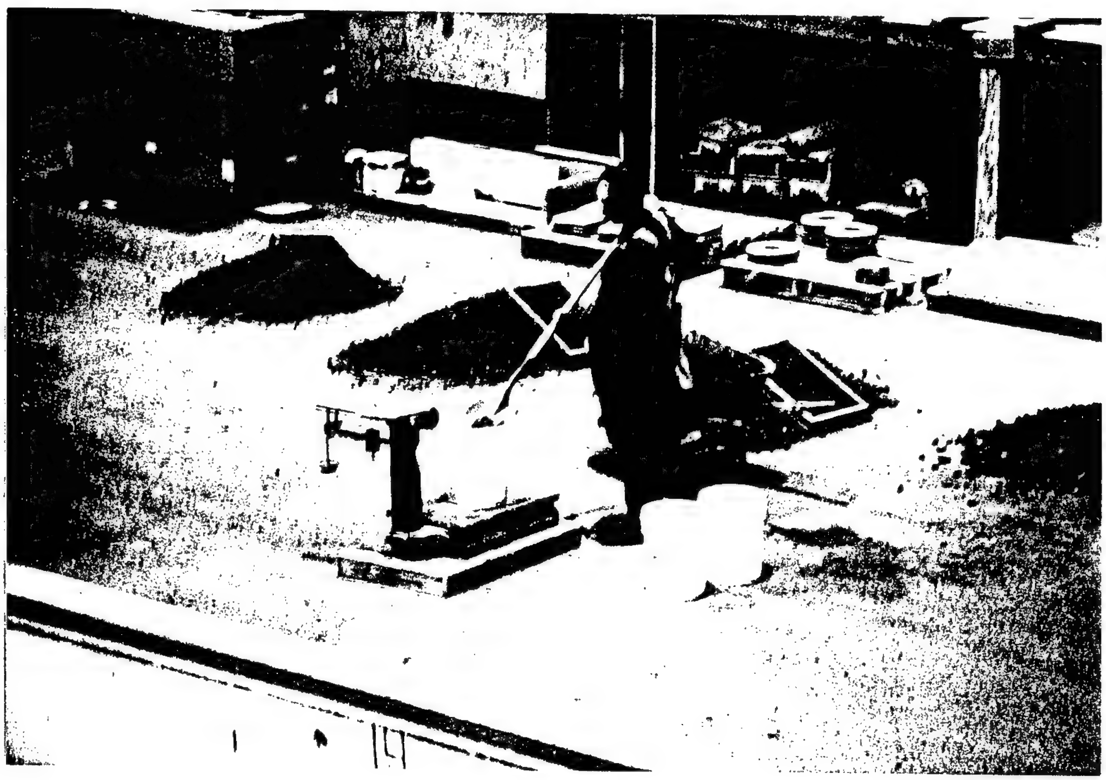

Figure 3.8 Weighing of Armor Rock Design Mix Prior to Blending in Concrete Mixer

Table 3.3
Armor Rock Size Distribution and Prototype Sizes for 1:24, 1:28.8, and 1:33.6 Scale

Cumulative % Passing	Sieve Size (inches)	1:24 Scale (inches)	1:28.8 Scale (inches)	1:33.6 Scale (inches)
100	1	24	28.8	33.6
70	7/8	21	25.2	29.4
25	3/4	18	21.6	25.2
10	5/8	15	18	21
0	1/2	12	14.4	16.8

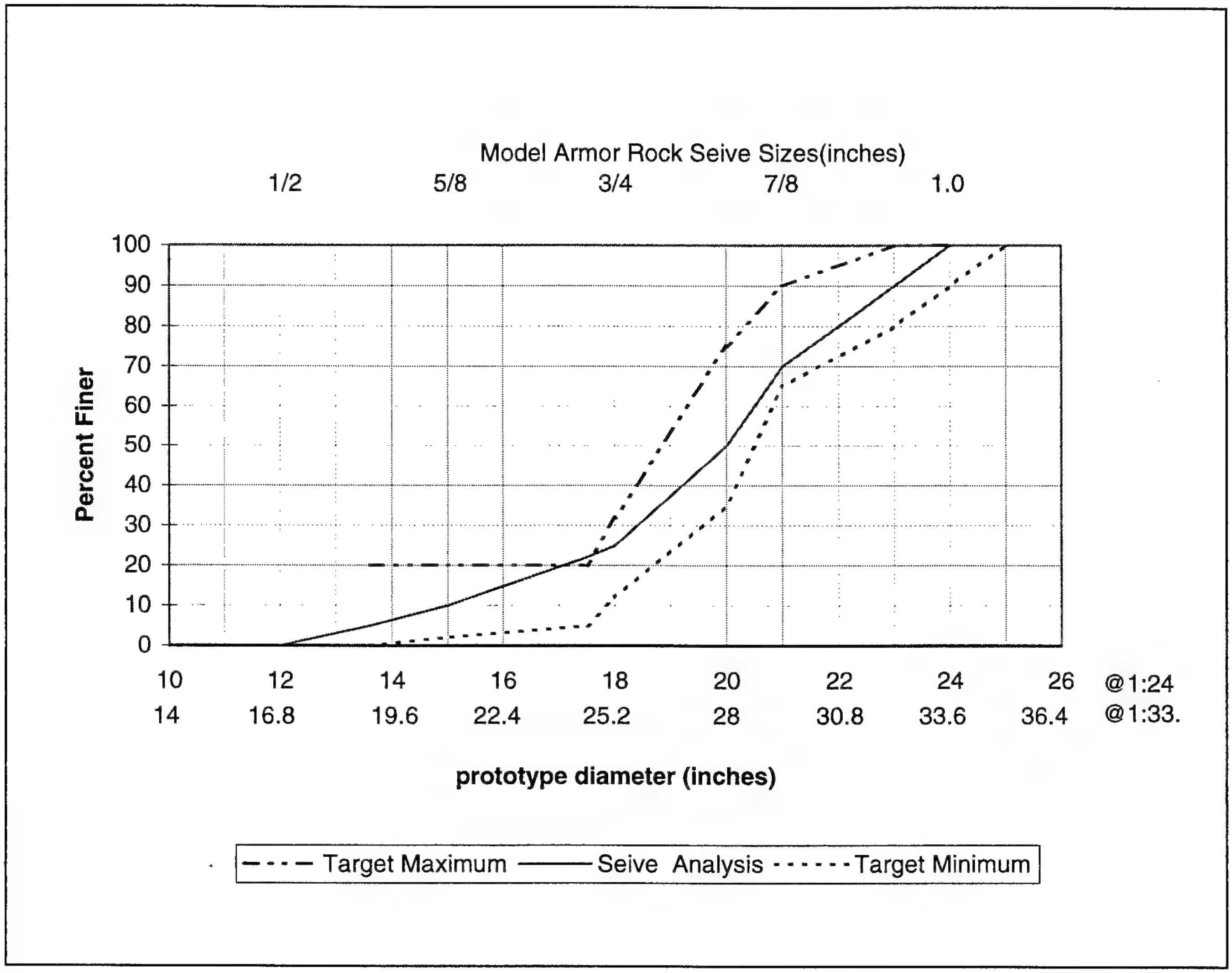

Figure 3.9
Model Armor Size Distribution with Target Maximum and Minimum Distributions.

3.4 Outfall Pipe

The prototype outfall is a concrete pipe with a 128 in. outside diameter (10.67 ft.), and a pipe wall thickness of 10 in. The model pipe used for phase A testing was 5 in. schedule 40 PVC which has outside diameter of 5.56 in. To exactly scale the model at 1:24 a 5.33 in. outside diameter pipe would have been required--not a common size. Figure 3.10 exhibits the cross section of the pipe and armor for the 1:24 scale model testing.

A determination of the correct model weight is necessary to preserve dynamic similitude. Five inch schedule 40 PVC has a dry weight [$W_{pvc(dry)}$] of 2.71 lbs/ft. The weight of the water in model pipe when full is

$$W_{pvc(full)} = \frac{\pi}{4}(I.D.)^2\gamma_{(FRESH\quad WATER)} = \frac{\pi}{4}\left(\frac{5}{12}ft\right)^2 62.4 lbs/ft^3 = 8.51 lbs/ft. \qquad (3.1)$$

The buoyant force on the model pipe in laboratory wave channel is

$$W_{pvc(displaced\ water)} = \frac{\pi}{4}(O.D.)^2\gamma_{(FRESH\quad WATER)} = \frac{\pi}{4}\left(\frac{5.56}{12}ft\right)^2 62.4 lbs/ft^3$$

$$= 10.52 lbs/ft. \qquad (3.2)$$

From these calculations the total weight of the model pipe when full of water and submerged is

$$W_{pvc\ model} = W_{pvc(dry)} + W_{pvc(full)} - W_{pvc(displaced\ water)} = 2.71\ lbs/ft + 8.51\ lbs/ft - 10.52\ lbs/ft$$

$$=0.7\ lbs/ft. \qquad (3.3)$$

The dry weight of the prototype pipe is

$$W_{p(dry)} = \frac{\pi}{4}\left[(O.D.)^2 - (I.D.)^2\right]\ \gamma_{concrete}$$

$$= \frac{\pi}{4}\left[(10.67ft)^2 - (9.0ft)^2\right]\ 150 lbs/ft^3 = 3870 lbs/ft. \qquad (3.4)$$

The weight of the fresh water in the prototype pipe is

$$W_{p(full)} = \frac{\pi}{4}(I.D)^2 \gamma_{(FRESH \quad WATER)} = \frac{\pi}{4}(9ft)^2 62.4 lbs/ft^3 = 3970 lbs/ft. \tag{3.5}$$

When prototype is full of fresh water and is also submerged in salt water the buoyant force on pipe is found by

$$W_{p(displaced\ water)} = \frac{\pi}{4}(O.D.)^2 \gamma_{(SEA \quad WATER)} = \frac{\pi}{4}(10.67ft)^2 64 lbs/ft^3 = 5723 lbs/ft. \tag{3.6}$$

From the above, the total weight of the prototype pipe when submerged is

$$W_{prototype} = W_{p(dry)} + W_{p(full)} - W_{p(displaced\ water)} = (3870 + 3970 - 5723) lbs/ft$$

$$= 2117 \text{ lbs/ft.} \tag{3.7}$$

Using Froude Scaling (with $\lambda = 1/24$) as described in Section 2.2 of this report, the minimum model weight required is

$$W_{PVC\_MODEL(MIN)} = \gamma_d \lambda^3 (W_{prototype}) = \gamma_d \lambda^2 (W_{prototype}/ \text{unit length}). \tag{3.8}$$

The specific weight of laboratory freshwater is 62.4 lb/ft^3 while that of the prototype ocean water is 64 lb/ft^3. This scales the density as

$$\gamma_d == \frac{\gamma_{MODEL}}{\gamma_{PROTOTYPE}} = \frac{62.4}{64.0} = 0.975. \tag{3.9}$$

By substituting (3.9) into (3.8), the required model weight is determined

$$W_{MODEL(MIN)} = \gamma_d \lambda^2 (2117 \text{ lbs/ft}) = 0.975(1/24)^2(2117 \text{ lbs/ft}) = 3.58 \text{ lbs/ft.} \tag{3.10}$$

The weight of the PVC pipe alone was 0.7 lbs/ft so an additional 2.88 lbs/ft was required for ballast in the model pipe. A number 8 reinforcing steel bar weighs 2.67 lbs/ft in air. The fully submerged weight of No. 8 rebar is

$$W_{total\ ballast} = W_{ballast\ (air)} - W_{ballast\ (displaced\ water)} = 2.67 lbs/ft - \frac{\pi}{4}(O.D).^2 \gamma_{(FRESH \quad WATER)}$$

$$= 2.67lbs/ft - \frac{\pi}{4}(1/12ft)^2 62.4lbs/ft^3 = 2.67 - 0.34 = 2.33lbs/ft. \qquad (3.11)$$

In order to achieve the required ballast of 2.88lbs/ft averaged over the pipe length, the No. 8 rebars were overlapped by 25% (1.25 * 2.33lbs/ft = 2.91lbs/ft).

For the testing with the revised design (Phase B) a scale ratio of 1:33.6 requires that the model pipe diameter be λ* prototype length = (1/33.6)*128 in. = 3.81 in. A four inch outside diameter aluminum pipe (inside diameter 3.90 in.) was chosen for use in the model. The four inch pipe has a dry weight [$W_{alum(dry)}$]of 1.0 lb/ft. The aluminum pipe full of water weighs

$$W_{alum(full)} = \frac{\pi}{4}(I.D.)^2 \gamma_{(FRESH\ \ WATER)} = \frac{\pi}{4}\left(\frac{3.9}{12}ft\right)^2 62.4lbs/ft^3 = 5.17lbs/ft. \qquad (3.12)$$

The buoyant force on the aluminum pipe in laboratory wave channel is

$$W_{alum(displaced\ water)} = \frac{\pi}{4}(O.D.)^2 \gamma_{(FRESH\ \ WATER)} = \frac{\pi}{4}\left(\frac{4}{12}ft\right)^2 62.4lbs/ft^3 = 5.45lbs/ft. \qquad (3.13)$$

From these calculations the total weight of the aluminum pipe when full of water and submerged is

$$W_{alum\ model} = W_{alum(dry)} + W_{alum(full)} - W_{alum(displaced\ water)} = 1.0\ lb/ft + 5.17\ lbs/ft - 5.45\ lbs/ft$$

$$= 0.72\ lbs/ft. \qquad (3.14)$$

Substituting λ= (1/33.6) into (3.8), the minimum weight required for the model is

$$W_{alum\_MODEL(MIN)} = \gamma_d \lambda^2 (W_{prototype}/\text{unit length}) = \left(\frac{62.4}{64.0}\right)\left(\frac{1}{33.6}\right)^2 2117lbs/ft = 1.82lbs/ft. \qquad (3.15)$$

The addition of one #8 rebar with a submerged weight per unit length of 2.33 lbs/ft within the four inch aluminum pipe exceeds the minimum required weight and that was used in the B Phase model. Figures 3.10 and 3.11 show the two model cross sections, with the prototype dimensions on the left, for each phase of testing.

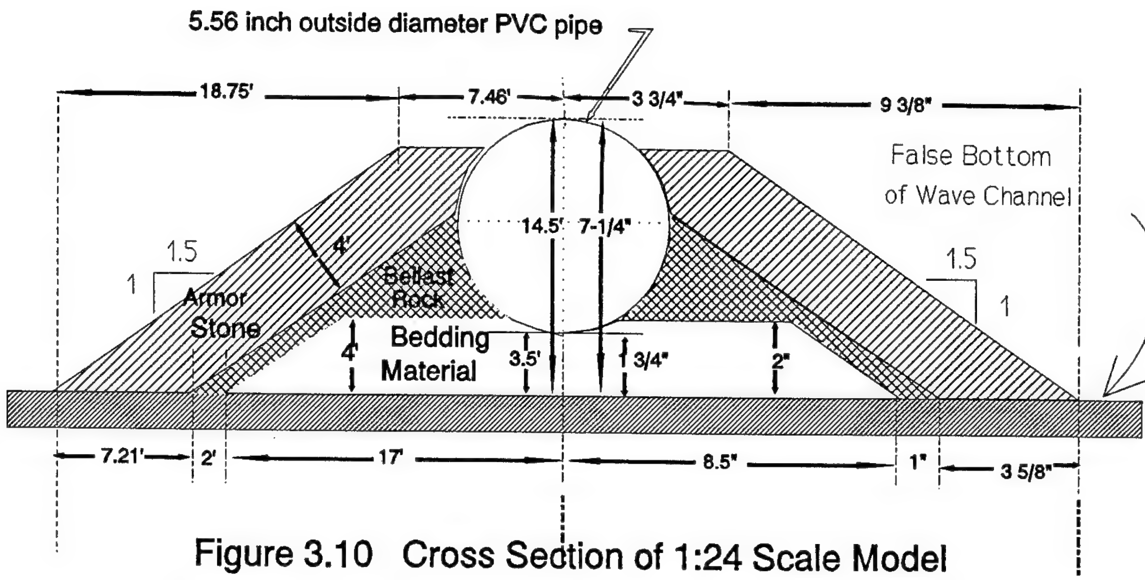

Figure 3.10 Cross Section of 1:24 Scale Model Showing Both Model and Prototype Dimensions

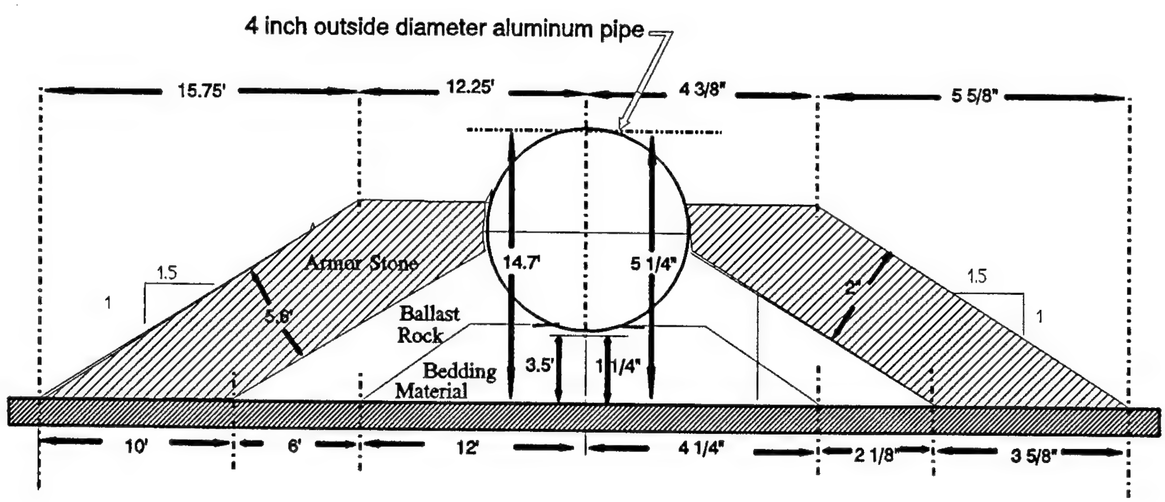

Figure 3.11 1:33.6 Scale Model Cross-section Showing Prototype and Model Dimensions

3.5 Model Construction

The model was constructed with the materials described in previous sections in several stages. The surface of the wave channel false bottom is smoothly finished concrete. Since the armor stones would rest directly upon this surface, six inch wide non-skid adhesive tape was placed upon the wave channel slabs as shown in Figure 3.12. The roughened surface provided a frictional effect approximating that which prototype armor stone might experience on a natural seabed.

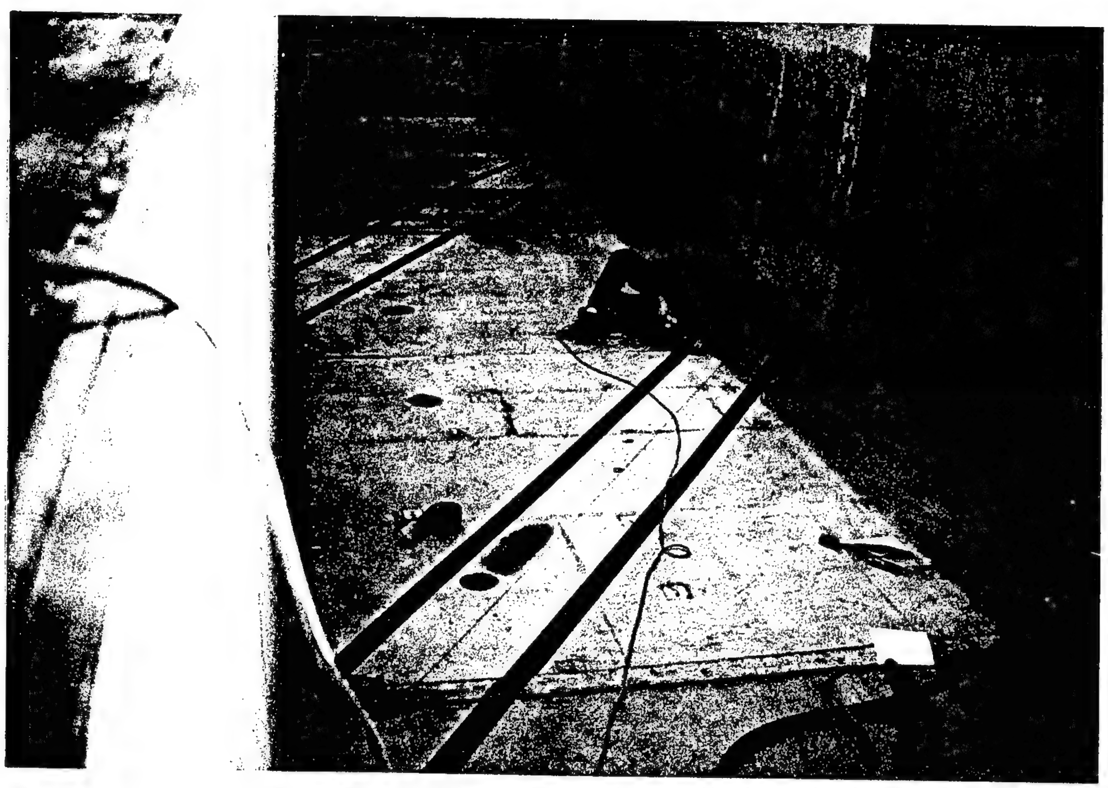

Figure 3.12. Installation of Six-inch Wide Non-skid Tape at Armor Toe Locations

The coarse aquarium sand was placed to model the bedding material upon which the prototype pipe is placed as is displayed in Figure 3.13. The model pipe was cut and bent at the locations necessary to keep the pipe parallel to the model profile slope, and duct tape sealed the cut. Reinforcing steel ballast was inserted into the pipe and ventilated end caps were placed over pipe ends prior to pipe installation. Hand pressure and body weight on the model pipe helped embed it into the aquarium sand.

Figure 3.13 Placement and Smoothing of Aquarium Sand by Use of a Wooden Template

Placement of the ballast stone then proceeded as is shown in Figure 3.14. The washed model ballast stones were carefully poured from buckets such that the bedding layer was not disturbed. As the photograph in Figure 3.14 indicates, the desired cross sectional thickness of this layer was obtained by screeding with a wood template. The ballast layer did not cover any of the non-skid tape.

Figure 3.14 Placement of the Ballast Stone Following Pipe "Setting" on Bedding Layer

The water level in the channel was then raised so that 12 inches of water covered the shallowest point of the model and armor rock was placed by dropping from five gallon buckets as is seen in Figure 3.15. The channel level was lowered leaving both models dry so that a plywood template could be used to ensure the minimum design cross section of the structure was in place prior to testing.

Figure 3.15. Placing of Armor Stone Design Mix Through Water

Following run A3420037, the water level was lowered so that the shallow model could be disassembled and a new reduced scale shallow model constructed. The pipe and ballast layer of rock were carefully removed. A wooden template similar to the one shown in Figure 3.13 was

employed to reshape the aquarium sand to meet the design cross-section. The aluminum pipe was then placed upon the aquarium sand and "set" into position. Following ballast stone installation the channel level was raised so that armor stone could be dropped through a minimum of 12 inches of water onto the model. The channel was then dewatered, and the surface screeded with a template to achieve the design cross section.

4.0 Experimental Tests

4.1 Overview

The Point Loma Reballasting construction and testing occurred between February 5 and February 22, 1996. Experimental tests were accomplished in two phases. Phase A testing modeled the prototype pipe at a 1:24 scale. The prototype length under Phase A testing was from station 73+65 to station 64+75. The design cross-section for the A design had the ballast stone placed to the springline of the pipe and the armor to approximately 11 and 1 o'clock. The initial test series of the A design was at a 1:24 scale. It was determined during the initial test series that the armor rock was unstable for wave heights of 60 feet or more. Testing was then done at a scale ratio of 1:28.8 and 1:33.6 which increased the apparant rock median diameters to 24 inches and 28 inches, respectively. Some significant rock motion was observed on the leeward toe of the shallow model with a prototype 16 second, 80 foot high wave but in all other 1:33.6 scale tests the 28 inch median diameter appeared to be a stable armor size to consider for a revised design.

Phase B testing modeled the prototype pipe at a 1:33.6 scale and simulated the prototype outfall from station 70+51 to station 63+79. The shallow model from the Phase A testing was removed and the B design model was built in its place. The B design had a more conservative ballast stone configuration where the stone met the pipe at approximately 3:30 and 8:30 rather than the springling (see Figure 3.11). Only the 1:33.6 scale ratio was used in the Phase B testing.

Significant deep model rock motion was observed two times out of thirty seven test runs in Phase A, and then only at the greater scale ratios where the median rock diameter was less than 28 in. Because of this, only the shallow portion of the model was rebuilt for the Phase B testing.

testing. Phase A testing consisted of 37 test runs and Phase B consisted of 28 test runs. Both phases of model testing were subjected to monochromatic and random waves.

Quantitative surveys at three locations were taken on both the shallow and deep models. A metal template was placed across the pipe and armor structure and eleven elevations were measured per transect. Each pipe model was surveyed prior to testing (in the dry) and at scale ratio changes (by a SCUBA diver) when the still water level of the channel was being decreased. The three pipe transect positions surveyed on each model are shown in Figure 4.1.

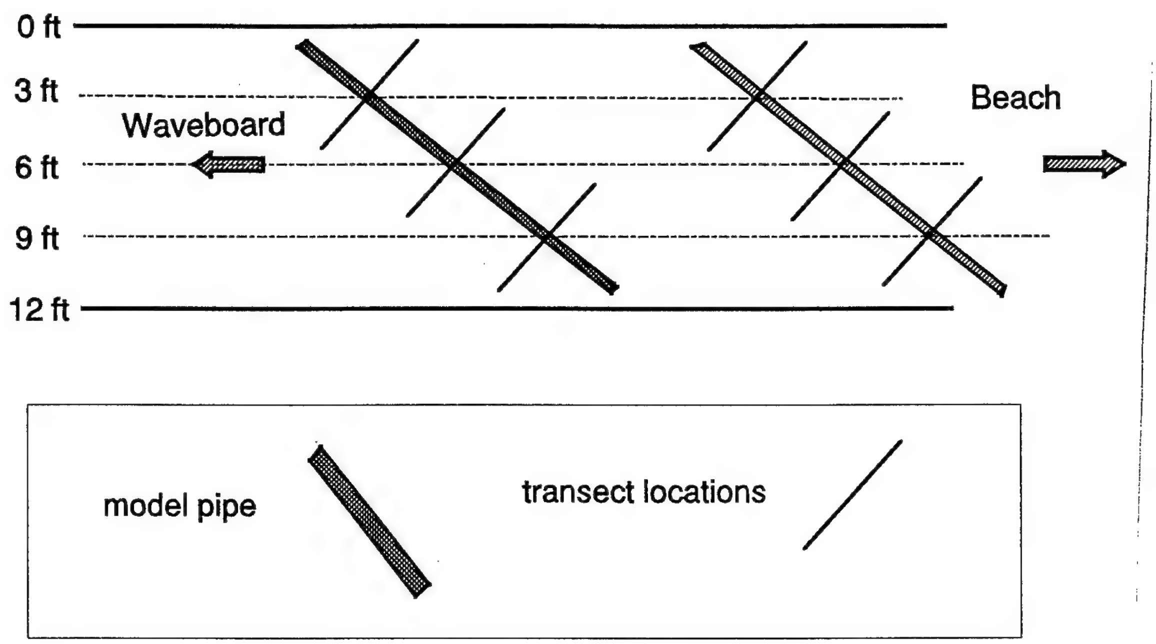

Figure 4.1 Plan View Schematic of Model Survey Locations

4.2 Instrumentation

Quantitative data recorded during each test run included wave profile and fluid velocity measurements with a total of nine data channels. Table 4.1 Indentifies each of the nine data channels in operation throughout the testing as well as their positions in the wave channel. All measurements are referenced with the following conventions:

X direction, horizontal positive toward beach with zero being location of the wavegauge closest to waveboard (data channel 1).

Y direction, horizontal positive away from the west wall of wave channel.

Z direction, vertical positive upwards with zero being the top of false channel bottom at the local position.

Table 4.1 Instrumentation

Channel	Instrument	Measurement	(X,Y,Z) in feet
1	Resistive Wave Gauge	wave profile	(0,1,*)
2	Resistive Wave Gauge	wave profile	(11.67,1,*)
3	Resistive Wave Gauge	wave profile	(23.67,1,*)
4	Resistive Wave Gauge	wave profile	(29.67,1,*)
5	Resistive Wave Gauge	wave profile	(35.67,1,*)
6	Horizontal Current Meter	Horizontal Velocity	(6.50,3.58,1.20)
7	Vertical Current Meter	Vertical Velocity	(6.50,3.58,1.20)
8	Horizontal Current Meter	Horizontal Velocity	(24.0,3.50,0.84) A [24.0,3.33,0.74] B
9	Vertical Current Meter	Vertical Velocity	(24.0,3.50,0.84) A [24.0,3.33,0.74] B

* Z Not applicable

When the Phase B model was re-constructed the current meter location was changed, and the revised positions are noted in the table. Figure 4.2 gives a plan view of the instrument locations and Figure 4.3 displays the east wall of channel and the line of gauges, cameras and meters.

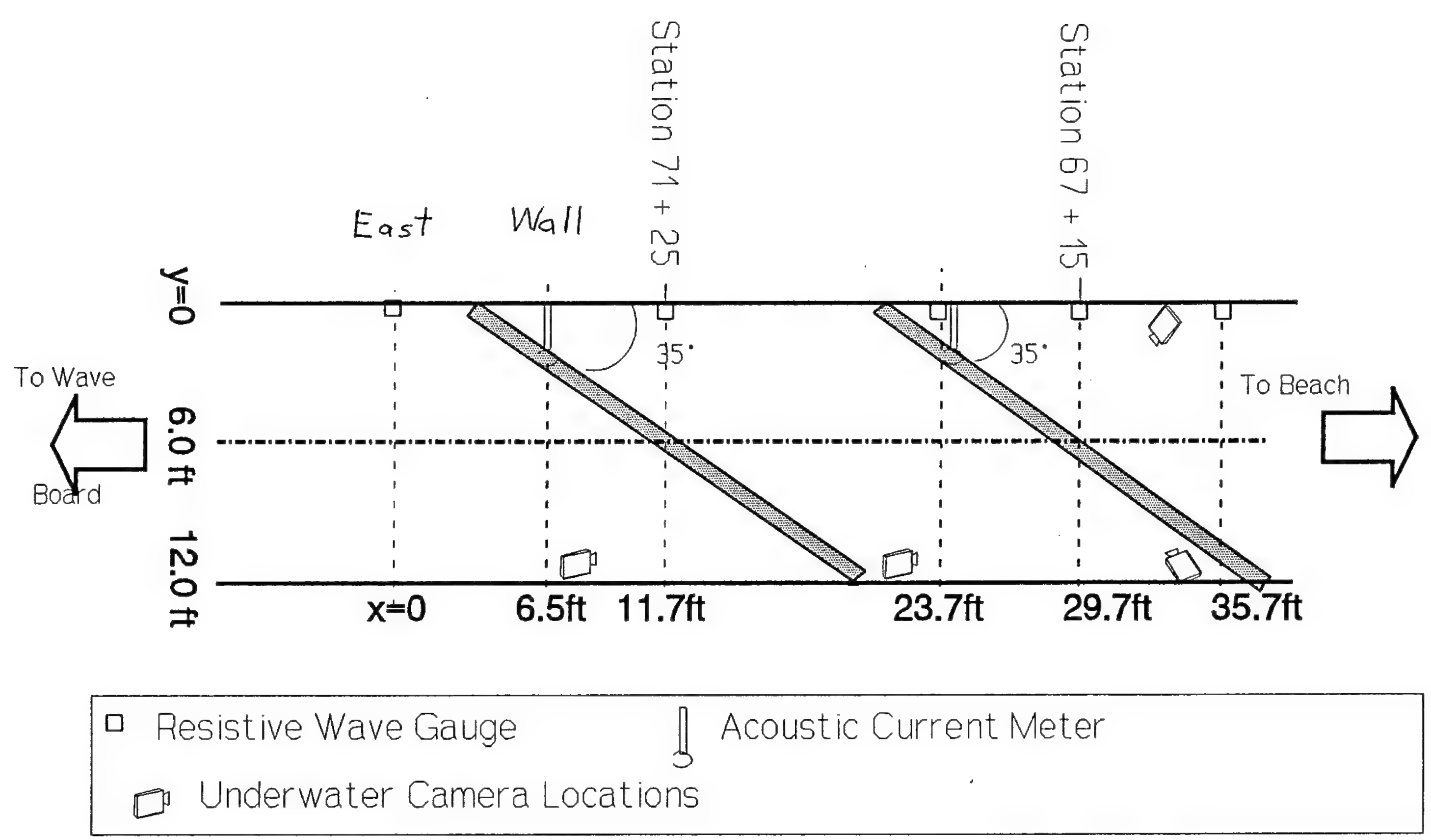

Figure 4.2 Plan View of Instrumentation in area of Deep and Shallow Models

Figure 4.3 Instrumented East Wall of Wave Channel

Each channel of raw data was pre-conditioned to a ±10 volt full scale reading, filtered using a 5 pole Bessel low-pass filter (f_0= 10 Hz), digitally sampled at 30 Hz and recorded with the Laboratory digital data acquisition system.

Calibration of the wave gauges occurred prior to testing and on the morning of February 14, 1996 and February 23, 1996. The procedure consists of raising the water level in the channel and correlating the voltage output from gauges with a video record of the surface elevation. Linear regression of the data provides calibration constants for each gauge.

Armor rock motion was observed through two underwater video cameras mounted below the water line. Figure 4.2 shows the various camera locations used during phase A and B. One other camera mounted on the control room roof recorded the water surface from above the

channel. Recordings were made of each run and had universal time code inserted on the VHS tapes for identification and synchronization with digitally recorded data.

4.3 Wave Conditions

Monochromatic waves are used to determine the wave height at which armor rock is unstable, also referred to as the "zero damage" wave height. Water depth and wave period are held constant while the wave generator displacement is increased to create larger waveheights in each consecutive test. Point Loma testing had a design prototype wave period of fourteen seconds. Prototype wave periods of 12, 16, 18, and 20 seconds were also examined in the experiment for completeness. All monochromatic runs were 200 seconds in length.

While monochromatic waves simulate well defined or narrow frequency band ocean swell, a more realistic approach to actual environmental conditions can be accomplished by a random wave spectrum. Because random waves include a full range of wave periods, the extreme waves caused by different wave frequency superposition can be modeled in the wave channel. The JONSWAP spectrum creates random sea conditions falling within the fully developed sea state equilibrium range. A peak enhancement factor allows the wave energy to be concentrated near the wave period of interest. All random waves during this testing used a peak enhancement factor of 3. The formulation of the JONSWAP spectrum follows: (Goda, 1985)

$$S(f) = \alpha H_{1/3}^2 T_p^{-4} f^{-5} \exp\left[-1.25(T_p f)^{-4}\right] \gamma_p^{\exp\left[-(T_p f-1)^2/2\sigma^2\right]} \tag{4.1}$$

where: $$\alpha = \frac{0.0624}{0.230 + 0.0336\gamma_p - 0.185(1.9+\gamma_p)^{-1}},$$

$$\sigma = \begin{cases} \sigma_a : f \le f_p \\ \sigma_b : f > f_p \end{cases}, \quad \gamma_p = 1 \quad through \quad 7, \sigma_a = 0.07, \sigma_b = 0.09, \text{ and}$$

f_p = the frequency at the spectral peak

$T_p =$ the inverse of f_p

$H_{1/3} =$ significant wave height

$\gamma_p =$ peak enhancement factor.

The significant wave height and peak frequency for the Jonswap spectrum were based on Dr. Frederic Raichlen's (California Institute of Technology) analysis of historical wave records in the vicinity of Point Loma. Each random wave test was 600 seconds in length.

4.4 Summary of test runs

Testing consisted of 65 individual runs. These runs are identified in Table 4.1. All runs begin with either "A" or "B", signifying the two model designs. The seven digits following the letter indicate scale ratio, prototype wave period, and consecutive run number. The first two numbers identify the scale ratio rounded to the nearest integer, so that the 1:28.8 scale reads as "29". The second two numbers indicate the target prototype wave period, the final three numbers are the consecutive run numbers 001 through 065.

The comments in Table 4.1 are based upon this author's observation of recorded video tapes. Each test run was reviewed and notes taken on armor motion and movement. The term "minor rock motion" is used in cases when less than 20 armor stones were displaced on that particular model during the test. "Major rock motion" is used when more than 20 armor stones were displaced during the test run on model pipe. Additionally, when armor movement was limited to a specific area, an attempt was made to note the locations of movement.

The wave heights and periods for the random wave runs represent the significant wave height ($H_{1/3}$) and spectral peak periods. The wave heights for the monochromatic wave runs is the average of twenty waves.

Table 4.1 Data Log Summary of Tests

RUN NUMBER	DATE & TIME	Model Depth @ Station: (feet)		Prototype Depth @ Station: (feet)		Model Wave		Prototype Wave		Random Peak En-hance-ment	Comments and observations from the test runs:
		67+15	71+25	67+15	71+25	Input Period (sec)	Meas. Height at wave gauge 3 (feet)	Period (sec) *[T_p for random waves]	Height (ft) *[$H_{1/3}$ for random waves]	(gamma)	
A2412001	Feb.14 1006	4.14	4.6	99.36	110.4	2.45	0.803	12	19.27		
A2412002	Feb.14 1020	4.14	4.6	99.36	110.4	2.45	1.573	12	37.75		shallow model had minor armor rock motion on leeward side
A2412003	Feb.14 1033	4.14	4.6	99.36	110.4	2.45	2.426	12	58.22		shallow model had major rock movement (both seaward and leeward) and waves were breaking over shallow model
A2412004	Feb.14 1104	4.14	4.6	99.36	110.4	2.45	1.67	12*	40.08*	3	
A2414005	Feb.14 1128	4.14	4.6	99.36	110.4	2.858	0.768	14	18.43		
A2414006	Feb.14 1136	4.14	4.6	99.36	110.4	2.858	1.699	14	40.06		
A2414007	Feb.14 1145	4.14	4.6	99.36	110.4	2.858	2.607	14	62.57		both models had minor armor rock movement on both the seaward and leeward faces
A2414008	Feb.14 1156	4.14	4.6	99.36	110.4	2.858	2.842	14	68.21		both models had minor armor rock movement on both faces and waves were breaking over both models
A2414009	Feb.14 1209	4.14	4.6	99.36	110.4	2.858	2.692	14	64.61		wave breaking over deep model with no rock motion on either model
A2414010	Feb.14 1357	4.14	4.6	99.36	110.4	2.858	2.50	14*	60.00*	3	shallow model had some minor rock movement and waves were breaking over shallow model
A2914011	Feb.14 1511	3.42	3.92	98.5	112.9	2.609	0.692	14	19.93		
A2914012	Feb.14 1518	3.42	3.92	98.5	112.9	2.609	1.326	14	38.19		
A2914013	Feb.14 1526	3.42	3.92	98.5	112.9	2.609	2.007	14	57.80		

Table 4.1 Data Log Summary of Tests

RUN NUMBER	DATE & TIME	Model Depth @ Station: (feet)		Prototype Depth @ Station: (feet)		Model Wave		Prototype Wave		Random Peak En-hance-ment	Comments and observations from the test runs:
		67+15	71+25	67+15	71+25	Input Period (sec)	Meas. Height at wave gauge 3 (feet)	Period (sec) *[T_p for random waves]	Height (ft) *[$H_{1/3}$ for random waves]	(gamma)	
A2914014	Feb.14 1607	3.42	3.92	98.5	112.9	2.609	2.414	14	69.52		
A2920015	Feb.14 1636	3.42	3.92	98.5	112.9	3.727	2.437	20	70.19		
A2920016	Feb.14 1647	3.42	3.92	98.5	112.9	3.727	2.902	20	83.58		
A2918017	Feb.15 1041	3.42	3.92	98.5	112.9	3.354	1.374	18	39.57		
A2918018	Feb.15 1049	3.42	3.92	98.5	112.9	3.354	2.048	18	58.98		shallow - minor rock movement on seaward facing slope
A2918019	Feb.15 1056	3.42	3.92	98.5	112.9	3.354	2.463	18	70.93		shallow - minor rock motion on seaward facing slope. deep - between 5 to 10 armor stones moved away from leeward toe
A2918020	Feb.15 1113	3.42	3.92	98.5	112.9	3.354	2.083	18*	60.00*	3	shallow - when a breaking wave occurred then sporadic minor rock motion was observed
A2916021	Feb.15 1133	3.42	3.92	98.5	112.9	2.981	1.226	16	35.31		
A2916022	Feb.15 1140	3.42	3.92	98.5	112.9	2.981	2.033	16	58.55		shallow - minor rock motion from leeward toe
A2916023	Feb.15 1147	3.42	3.92	98.5	112.9	2.981	2.775	16	79.92		shallow - major rock motion with 20 or more stones moving from seaward to leeward side of pipe. deep - between 5 to 10 stones were swept from leeward toe waves were breaking directly on shallow model
A2916024	Feb.15 1203	3.42	3.92	98.5	112.9	2.981	2.430	16*	69.98*	3	shallow - when a breaking wave occurred then sporadic minor rock motion was observed

Table 4.1 Data Log Summary of Tests

RUN NUMBER	DATE & TIME	Model Depth @ Station: (feet) 67+15	71+25	Prototype Depth @ Station: (feet) 67+15	71+25	Model Wave Input Period (sec)	Model Wave Meas. Height at wave gauge 3 (feet)	Prototype Wave Period (sec) *[T_p for random waves]	Prototype Wave Height (ft) *[$H_{1/3}$ for random waves]	Random Peak En-hance-ment (gamma)	Comments and observations from the test runs:
A3414025	Feb.15 1439	2.93	3.43	98.45	115.3	2.415	2.002	14	67.27		
A3414026	Feb.15 1639	2.93	3.43	98.45	115.3	2.415	1.770	14	59.47		
A3414027	Feb.15 1650	2.93	3.43	98.45	115.3	2.415	2.148	14	72.17		
A3414028	Feb.15	2.93	3.43	98.45	115.3	2.415	2.083	14*	69.99*	3	
A3416029	Feb.16 0846	2.93	3.43	98.45	115.3	2.760	1.617	16	54.33		
A3416030	Feb.16 0856	2.93	3.43	98.45	115.3	2.760	2.229	16	74.89		shallow model had rock movement on leeward face
A3416031	Feb.16 0925	2.93	3.43	98.45	115.3	2.760	2.083	16*	69.99*	3	
A3418032	Feb. 16 0946	2.93	3.43	98.45	115.3	3.105	1.608	18	54.03		
A3418033	Feb.16 0957	2.93	3.43	98.45	115.3	3.105	2.298	18	77.21		
A3418034	Feb.16 1011	2.93	3.43	98.45	115.3	3.105	2.083	18*	69.99*	3	
A3412035	Feb.16 1033	2.93	3.43	98.45	115.3	2.070	1.876	12	63.03		
A3420036	Feb.16 1046	2.93	3.43	98.45	115.3	3.450	1.604	20	53.89		
A3420037	Feb.16 1059	2.93	3.43	98.45	115.3	3.450	2.566	20	86.22		shallow model had minor rock motion on leeward face near camera mount

Table 4.1 Data Log Summary of Tests

RUN NUMBER	DATE & TIME	Model Depth @ Station: (feet)		Prototype Depth @ Station: (feet)		Model Wave		Prototype Wave		Random Peak En-hance-ment	Comments and observations from the test runs:
		67+15	71+25	67+15	71+25	Input Period (sec)	Meas. Height at wave gauge 3 (feet)	Period (sec) *[T_p for random waves]	Height (ft) *[$H_{1/3}$ for random waves]	(gamma)	
B3412038	Feb.21 1619	2.93	3.43	98.45	115.3	2.070	1.264	12	42.47		shallow model had monor rock motion on leeward face
B3414039	Feb.21 1635	2.93	3.43	98.45	115.3	2.415	1.348	14	45.29		armor rock that had been previously displaced was moving on channel bottom near both models
B3416040	Feb.21 1646	2.93	3.43	98.45	115.3	2.760	1.213	16	40.76		
B3418041	Feb.21 1656	2.93	3.43	98.45	115.3	3.105	1.100	18	36.96		
B3420042	Feb.22 0841	2.93	3.43	98.45	115.3	3.450	1.121	20	37.67		
B3412043	Feb.22 0854	2.93	3.43	98.45	115.3	2.070	1.899	12	63.81		shallow - minor rock motion from leeward toe and up on leeward slope
B3414044	Feb.22 0912	2.93	3.43	98.45	115.3	2.415	2.265	14	76.10		
B3416045	Feb.22 0927	2.93	3.43	98.45	115.3	2.760	1.850	16	62.16		
B3418046	Feb.22 0942	2.93	3.43	98.45	115.3	3.105	1.707	18	57.36		
B3420047	Feb.22 0953	2.93	3.43	98.45	115.3	3.450	1.683	20	56.55		
B3418048	Feb.22 1024	2.93	3.43	98.45	115.3	3.105	2.083	18*	69.99*	3	When a breaking wave occurred directly over shallow model, minor rock motion observed
B3416049	Feb.22 1059	2.93	3.43	98.45	115.3	2.760	2.083	16*	69.99*	3	same as run above

Table 4.1 Data Log Summary of Tests

RUN NUMBER	DATE & TIME	Model Depth @ Station: (feet) 67+15	Model Depth @ Station: (feet) 71+25	Prototype Depth @ Station: (feet) 67+15	Prototype Depth @ Station: (feet) 71+25	Model Wave: Input Period (sec)	Model Wave: Meas. Height at wave gauge 3 (feet)	Prototype Wave: Period (sec) *[T_p for random waves]	Prototype Wave: Height (ft) *[$H_{1/3}$ for random waves]	Random Peak En-hance-ment (gamma)	Comments and observations from the test runs:
B3414050	Feb.22 1121	2.93	3.43	98.45	115.3	2.415	2.083	14*	69.99*	3	When a breaking wave occurred directly over shallow model, minor rock motion observed
B3412051	Feb.22 1156	2.93	3.43	98.45	115.3	2.070	2.083	12*	69.99*	3	same as run above
B3420052	Feb.22 1209	2.93	3.43	98.45	115.3	3.45	2.083	20*	69.99*	3	same as run above
B3412053	Feb.22 1343	2.93	3.43	98.45	115.3	2.07	1.110	12	37.30		
B3414054	Feb.22 1353	2.93	3.43	98.45	115.3	2.415	2.087	14	70.12		shallow model had minor rock motion on leeward face
B3416055	Feb.22 1400	2.93	3.43	98.45	115.3	2.76	2.120	16	71.23		shallow model had minor rock motion on leeward face
B3418056	Feb.22 1419	2.93	3.43	98.45	115.3	3.105	2.016	18	67.74		
B3420057	Feb.22 1427	2.93	3.43	98.45	115.3	3.45	2.103	20	70.66		
B3412058	Feb.22 1452	2.93	3.43	98.45	115.3	2.07	1.020	12	34.27		
B3414059	Feb.22 1506	2.93	3.43	98.45	115.3	2.415	1.646	14	55.31		
B3416060	Feb.22 1518	2.93	3.43	98.45	115.3	2.76	2.252	16	75.67		shallow model had major armor rock motion on leeward face and waves were breaking over shallow model
B3418061	Feb.22 1526	2.93	3.43	98.45	115.3	3.105	2.369	18	79.60		
B3420062	Feb.22 1535	2.93	3.43	98.45	115.3	3.45	2.266	20	76.14		

Table 4.1 Data Log Summary of Tests

RUN NUMBER	DATE & TIME	Model Depth @ Station: (feet)		Prototype Depth @ Station: (feet)		Model Wave		Prototype Wave		Random Peak En-hance-ment	Comments and observations from the test runs:
		67+15	71+25	67+15	71+25	Input Period (sec)	Meas. Height at wave gauge 3 (feet)	Period (sec) *[T_p for random waves]	Height (ft) *[$H_{1/3}$ for random waves]	(gamma)	
B3414063	Feb.22 1612	2.93	3.43	98.45	115.3	2.415	1.786	14*	60.00*	3	
B3416064	Feb.22 1639	2.93	3.43	98.45	115.3	2.76	1.786	16*	60.00*	3	
B3412065	Feb.22 1703	2.93	3.43	98.45	115.3	2.07	1.786	12*	60.00*	3	

5.0 Results

5.1 Overview

Descriptions of the hydrodynamic environment and armor stone consolidation and displacement are presented for the 65 individual tests of the Point Loma reballast design. Wave climate is quantified in terms of wave period, wave height and horizontal velocities at the outfall models. For all waves the peak period and zero moment wave heights are used. For monochromatic waves the onshore and offshore maximum velocities are determined from an average of twenty waves. Random wave runs are further described in terms of zero moment horizontal velocities. Changes in the model profile during testing are quantified.

5.2 Analysis Methods

The armored outfall causes a fraction of the incident wave energy to be reflected back toward the wave board. In this experiment the incident and reflected wave components are not resolved because of the relatively deep locations of the structure and thus a smaller portion of reflected energy. The methods for separating incident and reflected waves used in earlier reports (Ruggerio, Freeman) could be performed. The water depth and the shoaling bottom used in these tests would result in small values of reflected wave energy and the waves passing the deeper and shallow models were considered to be unreflected incident waves.

Two measurements of wave height commonly used in experimental tests are the significant wave height, $H_{1/3}$, and the zero moment wave height, H_{mo}. The significant wave height is defined as the average height of the highest 1/3 of the waves recorded. The zero moment wave height is the height of a single wave component which has two times the energy of a measured wave system. For deep water waves with low steepness ($H/L < 0.0625$) $H_{1/3}$ equals H_{mo} . With

the height expressed as $H_{1/3}$ or H_{mo} and using the peak wave period, monochromatic and random waves are described as a single wave component. H_{mo} is also related to the root-mean-square wave height, H_{rms}, by the following equation

$$H_{mo} = \sqrt{2}H_{rms} = H_{1/3}\,. \qquad (5.1)$$

H_{mo} is the wave height parameter chosen for quantifying the water surface profile in this experiment.

5.3 Summary of Results

The data for this report follows the summary of test runs nomenclature provided in Table 4.1. These include video logs, surveys of model cross-section elevation, and wave climate analysis. The video logs comprise groups of consecutive tests. The underwater surveys were taken between scale changes. The video logs shown in Table 5.1 list the tape number on which the particular view can be found for a specified test run.

Table 5.1 Video Logs.

Video Tape No.	View of :	For Run Numbers:
1	Deep Model	A2412001-A2916024
2	Shallow Model	A2412001-A2916024
3	Surface Waves*	A2412001-A2916024
4	Deep Model	A3414025-B3416049
5	Shallow Model	A3414025-B3416049
6	Surface Waves*	A3414025-B3418048
7	Shallow Model Shoreward Side	B3414050-B3412065
8	Shallow Model Ocean Side	B3414050-B3412065
9	Surface Waves*	B3416049-B3412065

* A camera was mounted above the two dimensional channel giving an angled view of the wave surface from above.

5.3.1 Profile Measurements

For the model surveys, cross-section measurements have been averaged across the three transects of each model to provide mean profiles. Each of these profiles consists of a series of eleven measurements referenced to the surrounding bottom elevation. Tables 5.2, 5.3, 5.4, and Figures 5.1, 5.2, 5.3 show the offshore direction from pipe centerline as negative distances and the onshore direction from pipe centerline as positive distances. The algebraic sum average is also listed for the profiles which gives a damage estimate of the armor rock layer.

Table 5.2 and Figure 5.1 summarize the model profile changes in the shallow model during Phase A testing. By taking the shallow model average of all points the Phase A design armor loss would be equivalent to 7.2 inches in the prototype. Figure 5.1 shows the most significant armor loss at the shoulder of the structure on the lee side of the pipe. Comparing the shoreward shoulder loss to seaward shoulder loss (the average of the ± 2.75 and ± 4.25 points) the seaward side lost 0.555 inches (13.3 inches prototype) while the shoreward side lost 0.95 inches (22 inches) prototype during the thirty-seven Phase A test runs.

Table 5.3 and Figure 5.2 summarize the transect surveys taken on the deep model. The deep model experienced armor stone movement (as far as detected by video monitoring) only twice in thirty-seven test runs. The video cameras were moved and aimed at the B model for runs B3412038 through B3412065. Figure 5.2 shows that very little profile change occurred on the deep model between runs A3420037 and B3412065, so it appears the armor was very stable on the deep model throughout Phase B testing.

The deeper model steadily lost armor on the seaward sloped portion of the structure until equilibrium was achieved near the end of Phase A testing. In contrast, the shoreward side initially

lost armor material during test runs 1-10 (when testing D_{50} = 20 inches) and then gained material in the following fifty-five test runs. By taking the deep model average of all points, the Phase A armor loss would be 17.3 inches in the prototype.

Table 5.2 Average Cross-Sections for Phase A Shallow Model (inches)

	Distance from pipe centerline	Initial Survey	After A2414010	After A3420037
Deep	-13.625	0.55	0.87	0.67
	-10.5	1.6	2.58	2.32
	-7.375	4.42	4.35	3.70
	-4.25	5.53	5.01	4.81
	-2.75	5.53	5.27	5.14
Pipe Centerline	0	7.37	7.04	7.17
	2.75	6.19	5.86	5.14
	4.25	5.79	5.73	5.01
	7.375	4.22	3.96	3.62
	10.5	1.86	2.45	2.45
Shallow	13.625	0.28	0.09	0.55
All Points	Average	3.94	3.92	3.64

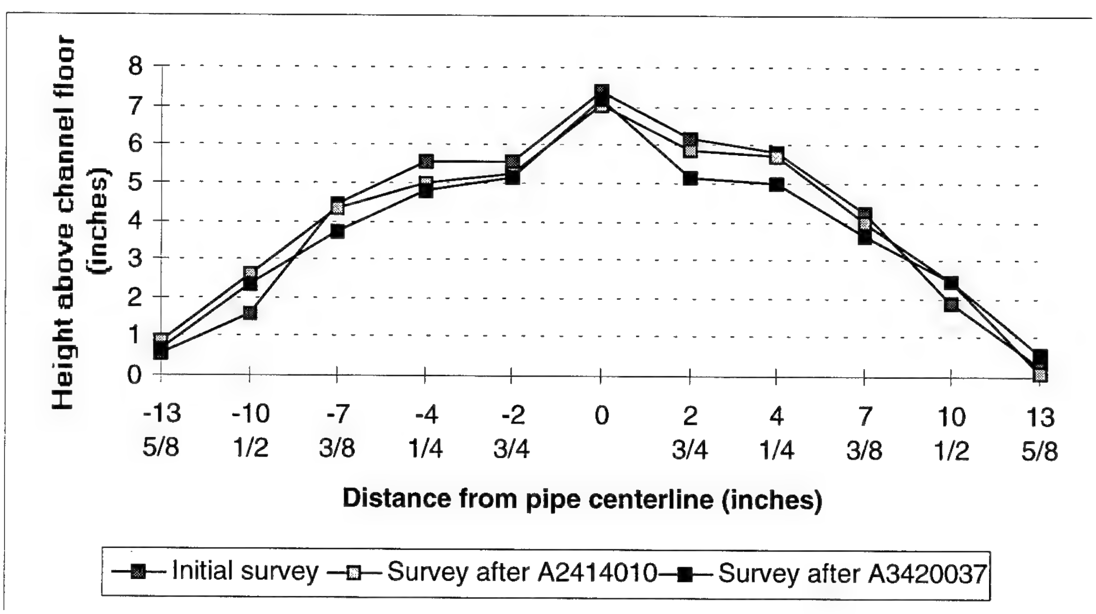

Figure 5.1 Profile Changes for Shallow Model Phase A Testing

Table 5.3 Average Cross-Sections for Phase A and Phase B Deeper Model (inches)

	Distance from pipe centerline	Initial Survey	After A2419010	After A3420037	After B3412065
Deep	-13.625	0.74	0.94	0.35	0.28
	-10.5	3.04	2.97	1.99	1.98
	-7.375	4.69	4.61	4.02	3.76
	-4.25	5.93	5.27	4.74	4.74
	-2.75	6.12	5.60	5.07	5.01
Pipe Centerline	0	7.37	7.37	7.37	7.11
	2.75	5.60	4.81	4.74	4.81
	4.25	5.14	4.35	4.48	4.29
	7.375	3.70	2.71	3.17	3.04
	10.5	1.79	0.94	1.40	1.33
Shallow	13.625	0.09	0.00	0.00	0.00
All Points	Average	4.02	3.60	3.39	3.30

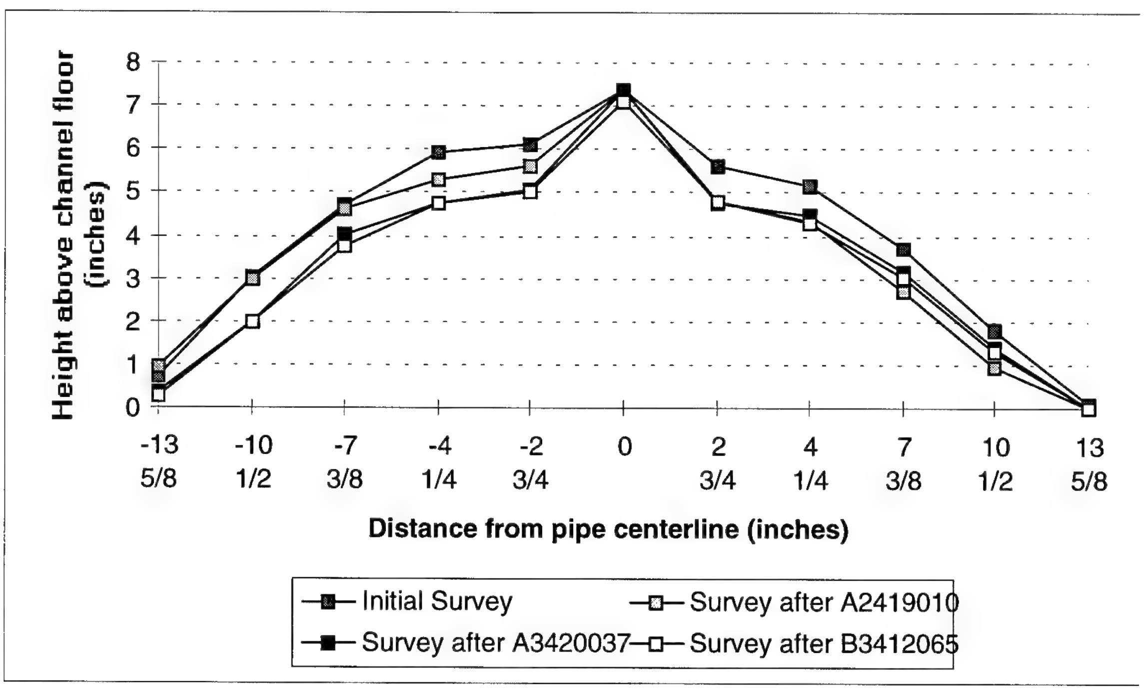

Figure 5.2 Profile Changes for Deep Model Phase A and B Testing

Table 5.4 Average Cross-Sections for Phase B Shallow Model (inches)

	Distance from pipe centerline	Initial Survey	After B3412065
Deep	-10	0.0	0.53
	-8	1.58	1.31
	-6	2.43	2.43
	-4	3.54	3.22
	-2	4.07	3.68
Pipe Centerline	0	5.32	5.32
	2	4.06	3.87
	4	3.61	3.22
	6	2.76	2.17
	8	1.71	1.64
Shallow	10	0.33	0.33
All Points	Average	2.67	2.52

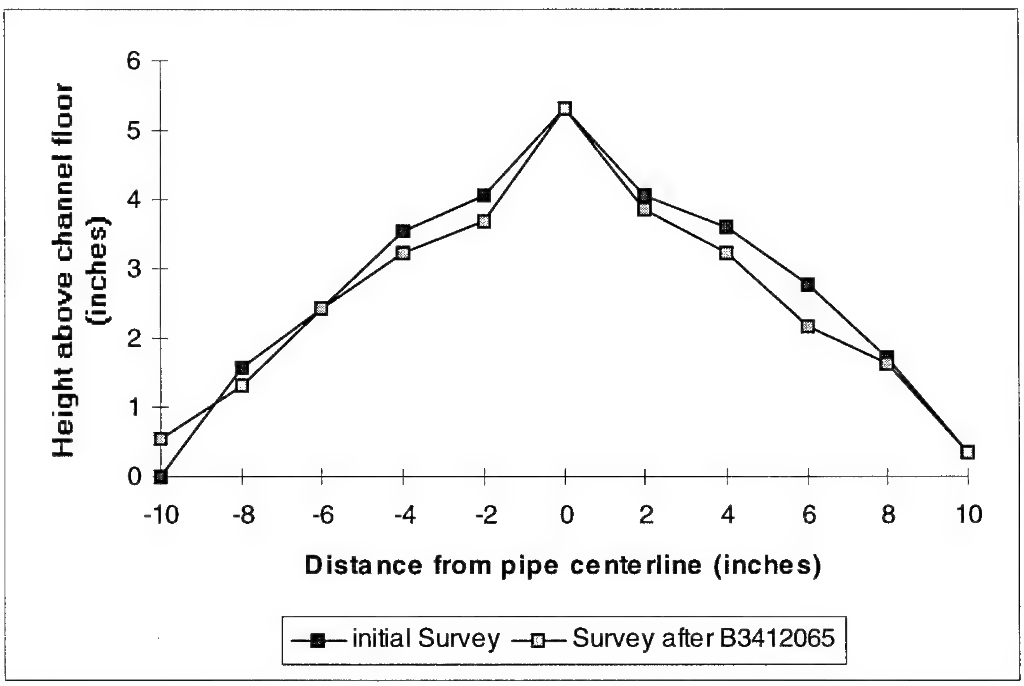

Figure 5.3 Profile Changes for Phase B Shallow Model Testing.

Table 5.4 and Figure 5.3 give the B model profile changes from its initial profile survey to the end of testing following run B3412065, a total of 28 tests. It is clear from Figure 5.3 that the leeward side of structure experienced the greatest loss of armor.

Figures 5.4, 5.5 and 5.6 chart the average change in cross section measurements of all surveys. For all three models (phase A deep and shallow, and phase B shallow) the greatest average negative (loss or consolidation of stone) change was on the onshore side of the model at the shoulder of the slope. The shallow model experienced average accumulation at the offshore toe for both phase A and B testing, while the deeper model experienced a net loss at the offshore toe. It is important to note that the shallow model in phase A was subjected to 37 test runs, the shallow model in phase B was subjected to 27 test runs, while the deeper model experienced all 65 runs.

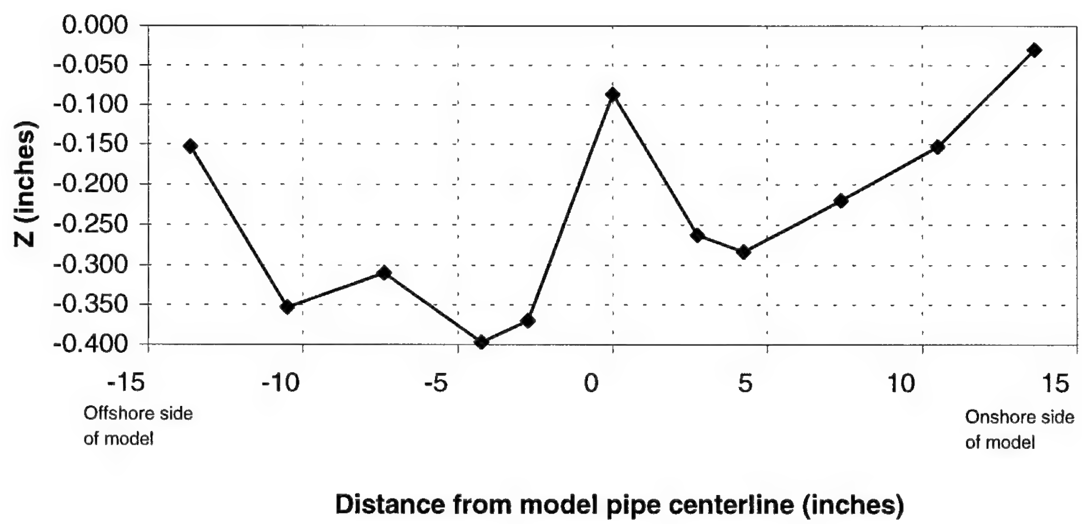

Figure 5.4 Average Change in Cross Section Elevation for All Deep Model Runs Phase A and B Testing

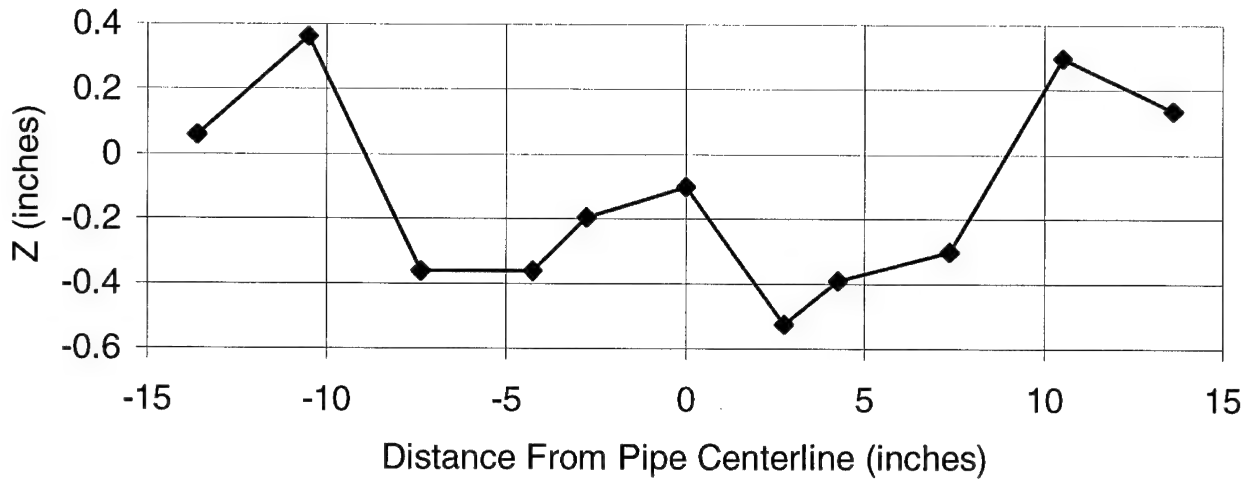

Figure 5.5 Average Change in Cross Section Elevation for Shallow Model Runs Phase A

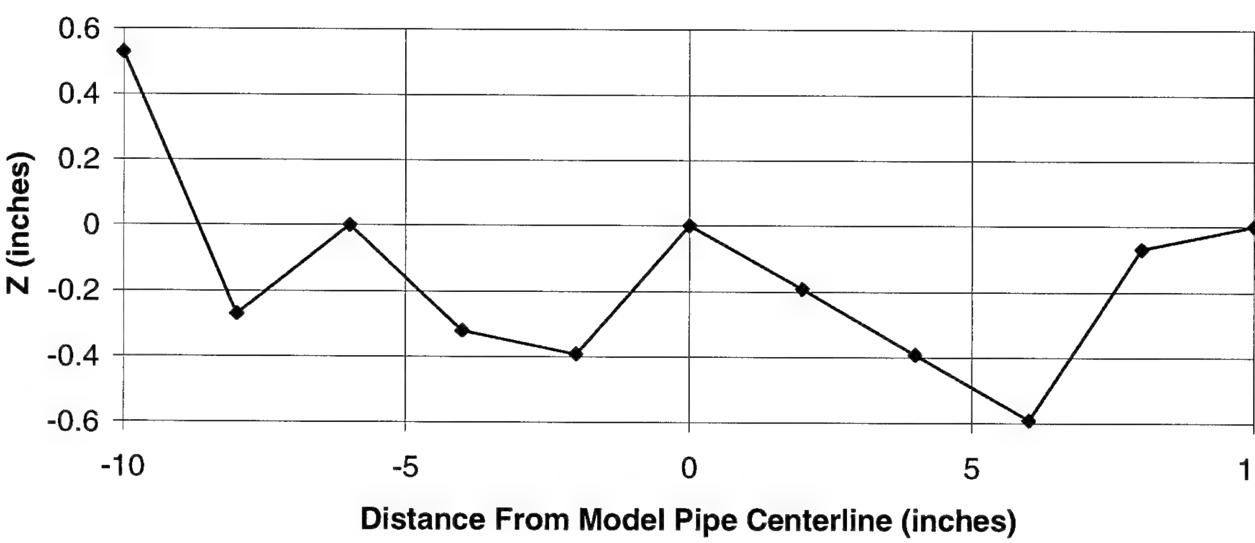

Figure 5.6 Average Change in Cross Section Elevation for Shallow Model Runs Phase B

The average profile change of the A design are compared to average profile change of the B design in Table 5.5. Additionally, information from Table 4.1 is included to reveal how much rock instability was present. It would appear that the D_{50} = 20 inches was quite stable on the shallow model, but in fact the shallow model experienced significant rock motion once, and minor rock motion four times in ten tests at this median rock diameter. Since only three transects were taken on each model, these averaged profile changes are good indicators of what occurred on the model instead of indicating armor stone stability. The greater number of test runs also have a large impact on the profile changes. The B design did experience less profile loss of material in the shallow model than the A design, but more importantly, the B design structure experienced less observable rock motion throughout the testing than did the A design.

Table 5.5 "A" Design Profile Change Compared to "B" Design Profile Change

Design	D_{50}	No. Test Runs	No. Runs where rock motion occurred	Average armor loss deep prototype	Average armor loss shallow prototype	Prototype average loss over entire length
A	20 in	10	5	10.1 in	0.5 in	5.3 in
A	24 &28 in	27	8	5.0 in	6.7 in	5.9 in
B	28 in	28	5	N/A	5.0 in	5.0 in

5.3.2 Tabular Results

The summary of model wave data shown in Table 5.6 includes wave profile measurements directly over the center of the deep and shallow models and currents just above the model pipes near the east wall of wave tank. Additional data obtained during the experiments are shown in the Appendix. Table 5.6 only lists the data from wave gauge 2, wave gauge 4, and the horizontal current measurements taken on channel 6 and 8 which are discussed in Section 4.2. The

horizontal currents shown are reported as average maximum onshore (+) and offshore (-) velocities at each current meter. For the monochromatic tests the values are obtained as the average computed over twenty waves. Random test runs list the zero moment velocity, or double amplitude velocity. Table 5.7 repeats the measurements for the prototype scale. Using Froude scaling as discussed in section two, wave height and water depth scale directly proportional to the length scale while wave period and velocity scale proportional to the square root of the length scale. Refer to Figure 4.2 (page 43) for locations of the measured wave heights and horizontal velocities.

Table 5.6 Summary of Hydrographic Data (model Scale)

Run Number	Depth in feet At Midpoint of Model		Deep Model H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at wave gauge no. 2					Shallow Model H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at wave gauge no. 4				
	deep	shallow	H	T	U	-U	Umo	H	T	U	-U	Umo
	model	model	(ft)	(sec)	(ft/sec)	(ft/sec)		(ft)	(sec)	(ft/sec)	(ft/sec)	
A2412001	4.6	4.14	0.959	2.451	0.827	-0.799		0.777	2.451	0.785	-0.685	
A2412002	4.6	4.14	1.944	2.453	1.554	-1.441		1.566	2.453	1.47	-1.295	
A2412003	4.6	4.14	2.847	2.447	2.334	-1.995		2.336	2.453	2.122	-1.738	
A2412004	4.6	4.14	1.539	2.406	1.285	-1.285	2.57	1.484	2.528	1.211	-1.211	2.421
A2414005	4.6	4.14	0.926	2.856	0.905	-0.87		0.865	2.856	0.861	-0.761	
A2414006	4.6	4.14	1.846	2.853	1.75	-1.562		1.707	2.861	1.647	-1.355	
A2414007	4.6	4.14	2.846	2.86	2.577	-2.023		2.592	2.86	2.329	-1.789	
A2414008	4.6	4.14	3.121	2.584	2.537	-1.97		2.714	2.589	2.361	-1.903	
A2414009	4.6	4.14	3.374	2.86	3.02	-2.254		2.308	2.856	2.57	-1.812	
A2414010	4.6	4.14	2.078	2.952	1.908	-1.908	3.816	1.968	2.952	1.787	-1.787	3.574
A2914011	3.92	3.42	0.818	2.609	0.767	-0.725		0.652	2.616	0.68	-0.619	
A2914012	3.92	3.42	1.58	2.609	1.445	-1.3		1.325	2.611	1.482	-1.189	
A2914013	3.92	3.42	2.311	2.609	2.301	-1.879		2.001	2.609	2.098	-1.513	
A2914014	3.92	3.42	2.836	2.611	2.535	-1.817		2.214	2.607	2.401	-1.662	
A2920015	3.92	3.42	2.453	3.726	2.967	-1.7		2.524	3.723	2.925	-1.614	
A2920016	3.92	3.42	2.759	3.726	3.286	-1.692		3.015	3.73	3.291	-1.666	
A2918017	3.92	3.42	1.285	3.353	1.615	-1.257		1.254	3.354	1.574	-1.108	
A2918018	3.92	3.42	1.998	3.356	2.599	-1.79		2.036	3.351	2.512	-1.614	
A2918019	3.92	3.42	2.805	3.356	3.071	-1.639		2.254	3.346	2.833	-1.642	
A2918020	3.92	3.42	1.747	3.31	1.896	-1.896	3.791	1.72	3.392	1.79	-1.79	3.58
A2916021	3.92	3.42	1.413	2.982	1.727	-1.148		1.423	2.981	1.696	-1.386	
A2916022	3.92	3.42	2.096	2.975	2.624	-2.055		2.161	2.981	2.554	-1.665	
A2916023	3.92	3.42	2.838	2.984	3.155	-2.142		2.635	2.988	2.958	-1.779	

Table 5.6 Summary of Hydrographic Data (model Scale)

Run Number	Depth in feet At Midpoint of Model		Deep Model H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at wave gauge no. 2					Shallow Model H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at wave gauge no. 4				
	deep	shallow	H	T	U	-U	Umo	H	T	U	-U	Umo
	model	model	(ft)	(sec)	(ft/sec)	(ft/sec)		(ft)	(sec)	(ft/sec)	(ft/sec)	
A2916024	3.92	3.42	1.884	3.017	2.111	-2.111	4.222	1.797	3.017	1.931	-1.931	3.862
A3414025	3.43	2.93	2.114	2.414	2.094	-1.767		1.873	2.412	1.904	-1.321	
A3414026	3.43	2.93	2.406	2.421	2.433	-1.844		1.32	2.43	1.816	-1.321	
A3414027	3.43	2.93	2.296	2.411	2.419	-1.885		2.048	2.416	2.106	-1.434	
A3414028	3.43	2.93	1.518	2.354	1.813	-1.813	3.625	1.558	2.344	1.669	-1.669	3.338
A3416029	3.43	2.93	1.833	2.756	2.226	-1.612		1.445	2.76	2.015	-1.313	
A3416030	3.43	2.93	2.61	2.761	2.766	-1.78		1.655	2.761	2.432	-1.424	
A3416031	3.43	2.93	1.646	2.69	1.92	-1.92	3.84	1.49	2.664	1.746	-1.746	3.491
A3418032	3.43	2.93	1.684	3.105	2.314	-1.572		1.699	3.102	2.346	-1.484	
A3418033	3.43	2.93	2.345	3.105	3.016	-1.901		2.549	3.107	3.071	-1.694	
A3418034	3.43	2.93	1.643	3.121	1.995	-1.995	3.99	1.573	3.051	1.841	-1.841	3.682
A3412035	3.43	2.93	1.873	2.072	1.832	-1.577		2.061	2.07	1.753	-1.413	
A3420036	3.43	2.93	1.836	3.451	2.493	-1.436		1.805	3.447	2.352	-1.357	
A3420037	3.43	2.93	2.665	3.451	3.041	-1.459		2.672	3.447	3.025	-1.442	
B3412038	3.43	2.93	1.205	2.07	1.304	-1.157		1.491	2.07	1.296	-1.171	
B3414039	3.43	2.93	1.47	2.416	1.502	-1.356		1.215	2.416	1.325	-1.086	
B3416040	3.43	2.93	1.258	2.76	1.512	-1.236		1.062	2.758	1.394	-1.023	
B3418041	3.43	2.93	1.159	3.102	1.638	-1.264		1.261	3.102	1.618	-1.141	
B3420042	3.43	2.93	1.285	3.453	1.661	-1.164		1.247	3.449	1.541	-1.04	
B3412043	3.43	2.93	1.98	2.074	1.929	-1.613		1.94	2.068	1.744	-1.331	
B3414044	3.43	2.93	2.156	2.411	2.21	-1.834		1.895	2.407	1.899	-1.299	
B3416045	3.43	2.93	1.92	2.758	2.355	-1.651		1.732	2.76	2.108	-1.348	
B3418046	3.43	2.93	1.754	3.105	2.466	-1.656		1.892	3.103	2.416	-1.49	

Table 5.6 Summary of Hydrographic Data (model Scale)

Run Number	Depth in feet At Midpoint of Model		Deep Model H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at wave gauge no. 2					Shallow Model H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at wave gauge no. 4				
	deep	shallow	H	T	U	-U	Umo	H	T	U	-U	Umo
	model	model	(ft)	(sec)	(ft/sec)	(ft/sec)		(ft)	(sec)	(ft/sec)	(ft/sec)	
B3420047	3.43	2.93	2.008	3.451	2.602	-1.44		1.89	3.446	2.383	-1.29	
B3418048	3.43	2.93	1.728	3.068	2.115	-2.115	4.23	1.678	3.068	1.816	-1.816	3.631
B3416049	3.43	2.93	1.638	2.772	1.974	-1.974	3.948	1.565	2.874	1.683	-1.683	3.366
B3414050	3.43	2.93	1.56	2.395	1.807	-1.807	3.613	1.537	2.304	1.56	-1.56	3.119
B3412051	3.43	2.93	1.473	2.167	1.633	-1.633	3.266	1.476	2.167	1.455	-1.455	2.909
B3420052	3.43	2.93	1.669	3.413	2.055	-2.055	4.109	1.615	3.413	1.772	-1.772	3.543
B3412053	3.43	2.93	1.528	2.075	2.09	-1.66		1.112	2.074	1.249	-1.039	
B3414054	3.43	2.93	2.251	2.411	2.345	-1.735		1.658	2.412	2.02	-1.341	
B3416055	3.43	2.93	2.359	2.761	2.633	-1.723		1.873	2.765	2.349	-1.341	
B3418056	3.43	2.93	2.073	3.107	2.85	-1.827		2.309	3.105	2.855	-1.579	
B3420057	3.43	2.93	2.421	3.451	2.996	-1.539		2.298	3.449	2.916	-1.364	
B3412058	3.43	2.93	1.23	2.061	1.495	-1.222		1.1	2.067	1.049	-0.884	
B3414059	3.43	2.93	1.894	2.416	2.205	-1.747		1.349	2.426	1.65	-1.229	
B3416060	3.43	2.93	2.597	2.76	2.894	-1.858		1.999	2.768	2.489	-1.446	
B3418061	3.43	2.93	2.453	3.105	3.122	-1.935		2.55	3.107	3.112	-1.592	
B3420062	3.43	2.93	2.804	3.451	3.118	-1.484		2.21	3.449	2.802	-1.33	
B3414063	3.43	2.93	1.418	2.471	1.641	-1.641	3.281	1.35	2.395	1.398	-1.398	2.795
B3416064	3.43	2.93	1.506	2.717	1.788	-1.788	3.576	1.448	2.859	1.553	-1.553	3.105
B3412065	3.43	2.93	1.386	2.193	1.498	-1.498	2.996	1.381	2.193	1.342	-1.342	2.684

Table 5.7 Summary of Hydrographic Data (Prototype Scale)

Run	Depth (ft) at:		Deep Outfall Section H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at station 71+15					Shallow Outfall Section H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at station 67+15				
Number	Station 67+15	Station 71+25	H (ft)	T (sec)	U (ft/sec)	-U (ft/sec)	Umo	Hmo (ft)	Tp (sec)	U (ft/sec)	-U (ft/sec)	Umo
A2412001	110.4	99.36	23.016	12.007	4.051	-3.914		18.648	12.007	3.846	-3.356	
A2412002	110.4	99.36	46.656	12.017	7.613	-7.059		37.584	12.017	7.201	-6.344	
A2412003	110.4	99.36	68.328	11.988	11.434	-9.773		56.064	12.017	10.396	-8.514	
A2412004	110.4	99.36	36.936	11.787	6.295	-6.295	12.59	35.616	12.385	5.93	-5.93	11.86
A2414005	110.4	99.36	22.224	13.991	4.434	-4.262		20.76	13.991	4.218	-3.728	
A2414006	110.4	99.36	44.304	13.977	8.573	-7.652		40.968	14.016	8.069	-6.638	
A2414007	110.4	99.36	68.304	14.011	12.625	-9.911		62.208	14.011	11.41	-8.764	
A2414008	110.4	99.36	74.904	12.659	12.429	-9.651		65.136	12.683	11.566	-9.323	
A2414009	110.4	99.36	80.976	14.011	14.795	-11.042		55.392	13.991	12.59	-8.877	
A2414010	110.4	99.36	49.872	14.462	9.348	-9.348	18.695	47.232	14.462	8.755	-8.755	17.509
A2914011	112.896	98.496	23.5584	14.001	4.116	-3.891		18.7776	14.039	3.331	-3.032	
A2914012	112.896	98.496	45.504	14.001	7.755	-6.977		38.16	14.012	7.26	-5.825	
A2914013	112.896	98.496	66.5568	14.001	12.348	-10.084		57.6288	14.001	10.278	-7.412	
A2914014	112.896	98.496	81.6768	14.012	13.604	-9.751		63.7632	13.991	11.762	-8.142	
A2920015	112.896	98.496	70.6464	19.996	15.923	-9.123		72.6912	19.98	14.33	-7.907	
A2920016	112.896	98.496	79.4592	19.996	17.635	-9.08		86.832	20.017	16.123	-8.162	
A2918017	112.896	98.496	37.008	17.994	8.667	-6.746		36.1152	17.999	7.711	-5.428	
A2918018	112.896	98.496	57.5424	18.01	13.948	-9.606		58.6368	17.983	12.306	-7.907	
A2918019	112.896	98.496	80.784	18.01	16.481	-8.796		64.9152	17.957	13.879	-8.044	
A2918020	112.896	98.496	50.3136	17.763	10.173	-10.173	20.345	49.536	18.203	9.606	-9.606	19.212
A2916021	112.896	98.496	40.6944	16.003	9.268	-6.161		40.9824	15.998	8.309	-6.79	
A2916022	112.896	98.496	60.3648	15.966	14.082	-11.028		62.2368	15.998	12.512	-8.157	

Table 5.7 Summary of Hydrographic Data (Prototype Scale)

Run	Depth (ft) at:		Deep Outfall Section H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at station 71+15					Shallow Outfall Section H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at station 67+15				
Number	Station 67+15	Station 71+25	H (ft)	T (sec)	U (ft/sec)	-U (ft/sec)	Umo	Hmo (ft)	Tp (sec)	U (ft/sec)	-U (ft/sec)	Umo
A2916023	112.896	98.496	81.7344	16.014	16.932	-11.495		75.888	16.035	14.491	-8.715	
A2916024	112.896	98.496	54.2592	16.191	11.329	-11.329	22.658	51.7536	16.191	10.363	-10.363	20.726
A3414025	115.248	98.448	71.0304	13.993	12.138	-10.243		62.9328	13.981	11.037	-7.657	
A3414026	115.248	98.448	80.8416	14.033	14.103	-10.689		44.352	14.086	10.527	-7.657	
A3414027	115.248	98.448	77.1456	13.975	14.022	-10.926		68.8128	14.004	12.208	-8.312	
A3414028	115.248	98.448	51.0048	13.645	10.506	-10.506	21.012	52.3488	13.587	9.675	-9.675	19.349
A3416029	115.248	98.448	61.5888	15.975	12.903	-9.344		48.552	15.998	11.68	-7.611	
A3416030	115.248	98.448	87.696	16.004	16.033	-10.318		55.608	16.004	14.097	-8.254	
A3416031	115.248	98.448	55.3056	15.593	11.13	-11.13	22.259	50.064	15.442	10.118	-10.118	20.236
A3418032	115.248	98.448	56.5824	17.998	13.413	-9.112		57.0864	17.981	13.599	-8.602	
A3418033	115.248	98.448	78.792	17.998	17.482	-11.019		85.6464	18.01	17.801	-9.819	
A3418034	115.248	98.448	55.2048	18.091	11.564	-11.564	23.128	52.8528	17.685	10.672	10.672	21.343
A3412035	115.248	98.448	62.9328	12.01	10.619	-9.141		69.2496	11.999	10.161	-8.191	
A3420036	115.248	98.448	61.6896	20.004	14.451	-8.324		60.648	19.981	13.633	-7.866	
A3420037	115.248	98.448	89.544	20.004	17.627	-8.457		89.7792	19.981	17.535	-8.359	
B3412038	115.248	98.448	40.488	11.999	7.559	-6.707		50.0976	11.999	7.512	-6.788	
B3414039	115.248	98.448	49.392	14.004	8.706	-7.86		40.824	14.004	7.68	-6.295	
B3416040	115.248	98.448	42.2688	15.998	8.764	-7.165		35.6832	15.987	8.08	-5.93	
B3418041	115.248	98.448	38.9424	17.981	9.495	-7.327		42.3696	17.981	9.379	-6.614	
B3420042	115.248	98.448	43.176	20.015	9.628	-6.747		41.8992	19.992	8.932	-6.028	
B3412043	115.248	98.448	66.528	12.022	11.182	-9.35		65.184	11.987	10.109	-7.715	
B3414044	115.248	98.448	72.4416	13.975	12.81	-10.631		63.672	13.952	11.008	-7.53	

Table 5.7 Summary of Hydrographic Data (Prototype Scale)

Run	Depth (ft) at:		Deep Outfall Section H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at station 71+15					Shallow Outfall Section H, T corresponds to H_{mo}, T_p respectfully for random wave conditions at station 67+15				
Number	Station 67+15	Station 71+25	H (ft)	T (sec)	U (ft/sec)	-U (ft/sec)	Umo	Hmo (ft)	Tp (sec)	U (ft/sec)	-U (ft/sec)	Umo
B3416045	115.248	98.448	64.512	15.987	13.651	-9.57		58.1952	15.998	12.219	-7.814	
B3418046	115.248	98.448	58.9344	17.998	14.294	-9.599		63.5712	17.987	14.004	-8.637	
B3420047	115.248	98.448	67.4688	20.004	15.083	-8.347		63.504	19.975	13.813	-7.478	
B3418048	115.248	98.448	58.0608	17.784	12.26	-12.26	24.519	56.3808	17.784	10.524	-10.524	21.047
B3416049	115.248	98.448	55.0368	16.068	11.443	-11.443	22.885	52.584	16.659	9.756	-9.756	19.511
B3414050	115.248	98.448	52.416	13.883	10.472	-10.472	20.943	51.6432	13.355	9.04	-9.04	18.079
B3412051	115.248	98.448	49.4928	12.561	9.466	-9.466	18.932	49.5936	12.561	8.431	-8.431	16.862
B3420052	115.248	98.448	56.0784	19.784	11.909	-11.909	23.818	54.264	19.784	10.269	-10.269	20.537
B3412053	115.248	98.448	51.3408	12.028	12.115	-9.622		37.3632	12.022	7.24	-6.023	
B3414054	115.248	98.448	75.6336	13.975	13.593	-10.057		55.7088	13.981	11.709	-7.773	
B3416055	115.248	98.448	79.2624	16.004	15.262	-9.987		62.9328	16.027	13.616	-7.773	
B3418056	115.248	98.448	69.6528	18.01	16.52	-10.59		77.5824	17.998	16.549	-9.153	
B3420057	115.248	98.448	81.3456	20.004	17.366	-8.921		77.2128	19.992	16.903	-7.906	
B3412058	115.248	98.448	41.328	11.947	8.666	-7.083		36.96	11.981	6.081	-5.124	
B3414059	115.248	98.448	63.6384	14.004	12.781	-10.127		45.3264	14.062	9.564	-7.124	
B3416060	115.248	98.448	87.2592	15.998	16.775	-10.77		67.1664	16.045	14.428	-8.382	
B3418061	115.248	98.448	82.4208	17.998	18.097	-11.216		85.68	18.01	18.039	-9.228	
B3420062	115.248	98.448	94.2144	20.004	18.074	-8.602		74.256	19.992	16.242	-7.709	
B3414063	115.248	98.448	47.6448	14.323	9.509	-9.509	19.018	45.36	13.883	8.10	-8.10	16.201
B3416064	115.248	98.448	50.6016	15.749	10.364	-10.364	20.728	48.6528	16.572	8.999	-8.999	17.998
B3412065	115.248	98.448	46.5696	12.712	8.683	-8.683	17.366	46.4016	12.712	7.799	-7.779	15.558

5.3.3 Graphical Results

The graphs of wave heights and horizontal velocities present data measured from the deepest wave gauge, the current meter and wave gauge near the deep model center, and the current meter and wave gauge at the center of the shallow model. Both wave heights and horizontal velocities are presented in dimensionless form and compared to the theoretical limits obtained using Dean's stream function theory (Dean, 1974). The water depth is non-dimensionlized by the deep water wavelength, L_o. Linear wave theory determines this value according to the following equation

$$L_o = \frac{gT^2}{2\pi}, \qquad (5.2)$$

where L_o= linear wave theory deep water wavelength, g = gravitational constant, and T = wave period. The zero moment wave heights are non-dimensionalized in the same way as the water depth. Figures 5.7, 5.8 and 5.9 present these wave steepness versus wavelength measurements at the offshore wave gauge, the deep model center, and the shallow model center. The theoretical breaking limit by Dean Stream Function Theory ($H/H_b = 1$) is shown for comparison as is $H/H_b = 0.75$. For this experiment, the offshore wave gauge measurements agree with theory in that deepwater waves may attain 75% of the theoretical breaking height.

Graphical comparisons of the maximum horizontal velocities versus wavelength are shown for several of the test series in Figures 5.10 through 5.13. The velocities are non-dimensionalized by the ratio of the wave height divided by the wave period and the depth is again non-dimensionalized by the deep water wavelength. Dean (1974) theoretical dimensionless velocities are shown for comparison. The majority of the theoretical velocities were interpolated from

Stream Function tables for s/h values as shown in Table 5.8. The only dimensionless velocity that was not interpolated was for s/h = 0.3 which is listed directly in the tables.

Table 5.8 Values of s/h Used to Interpolate Dimensionless Velocities from Stream Function Tables

	water depth h		vertical distance from false bottom of channel to current meter s		Corresponding s/h value used to interpolate the dimensionless horizontal velocity from tables	
Run Numbers	over deep current meter (feet)	over shallow current meter (feet)	deep current meter (feet)	shallow current meter (feet)	Deep Model	Shallow Model
A2412001 - A2414010	5.10	4.60	1.198	0.843	0.235	0.183
A2914011- A2916024	4.42	3.92	1.198	0.843	0.271	0.215
A3414025- A3420037	3.93	3.43	1.198	0.843	0.30*	0.246
B3412038- B3412065	3.93	3.43	1.198	0.735	0.30*	0.214

*No interpolation required for this value of s/h.

The lower limit shown in the graphs, Deans Case D, represents the theoretical maximum wave height, $H/H_b = 1.0$. The upper limit, Deans Case A, represents the ratio of $H/H_b = 0.25$. Points plotted are monochromatic wave runs (M) and random wave runs (R). The random wave zero moment (double amplitude) velocities shown in Table 5.6 are divided by two for the graphical data.

The random tests with significant wave heights up to 70 feet provide smaller H/H_b values and $\frac{U_{max}}{H/T}$ values than the extreme monochromatic tests because the random results are statistical averages, not maximum observed conditions. For most runs the data conform well in comparison to the maximum velocity trends predicted by theory.

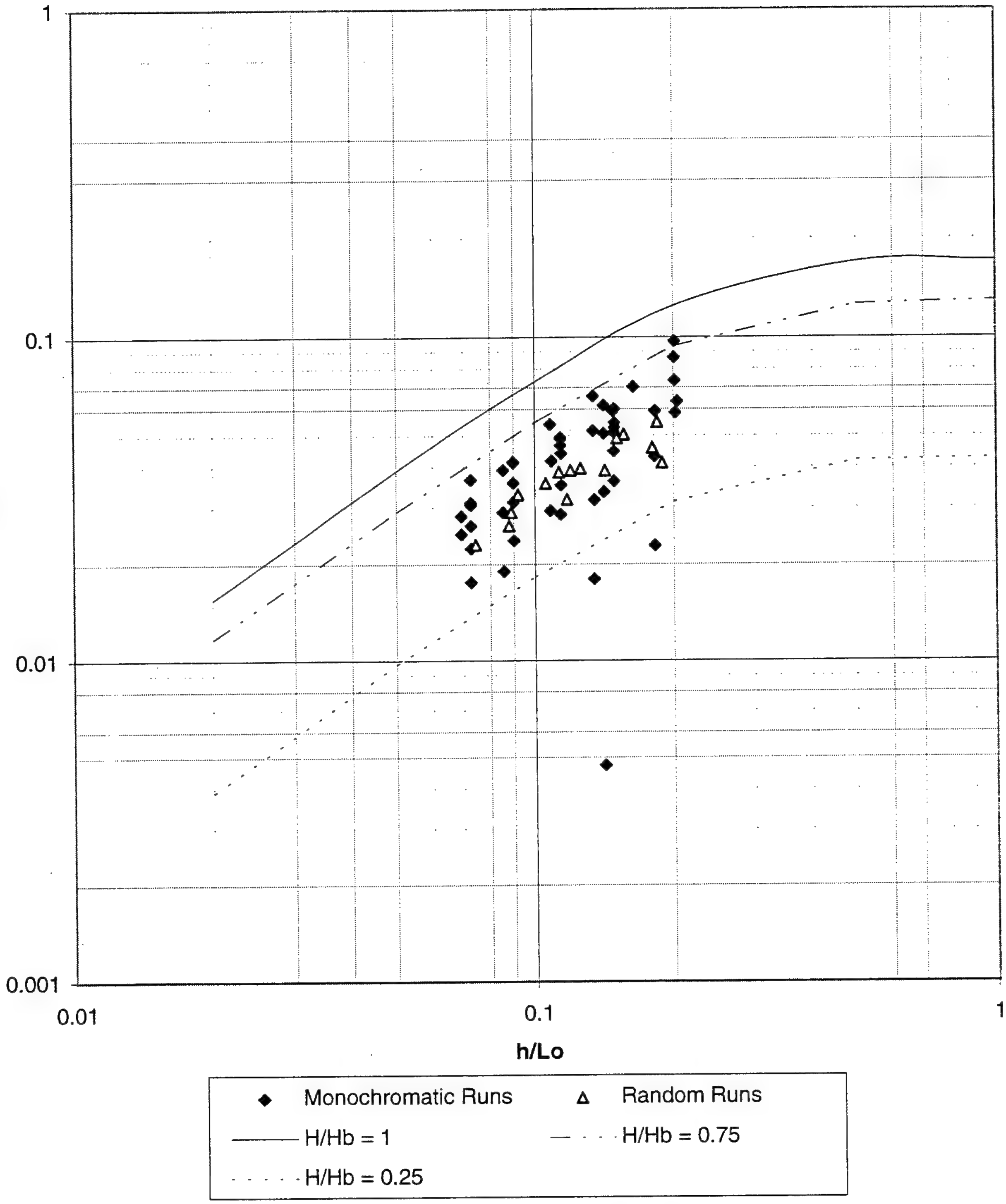

Figure 5.7 Wave Steepness Versus Relative Water Depth at the Offshore Wave Gauge

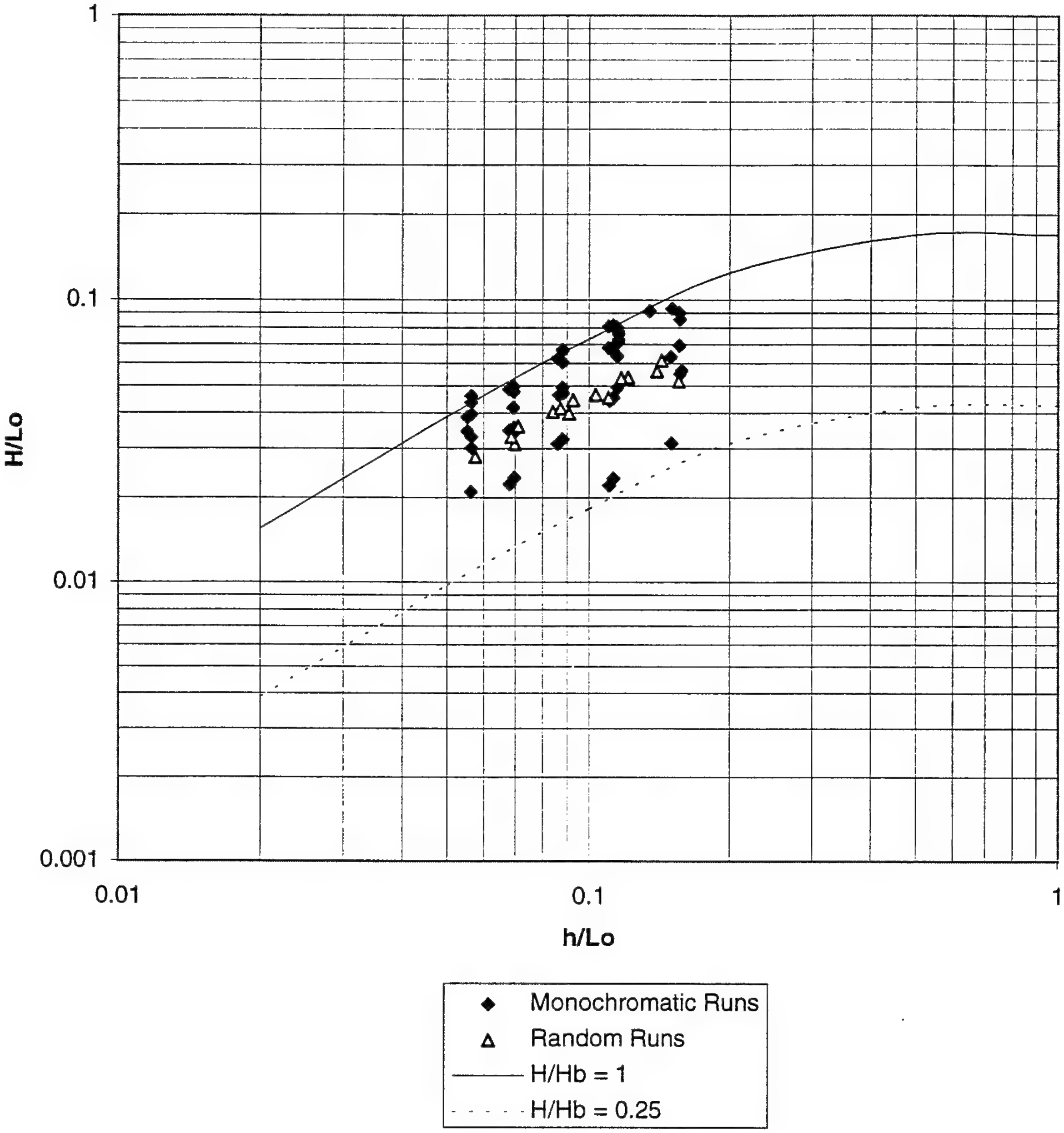

Figure 5.8 Wave Steepness Versus Relative Water Depth at the Deep Model Center

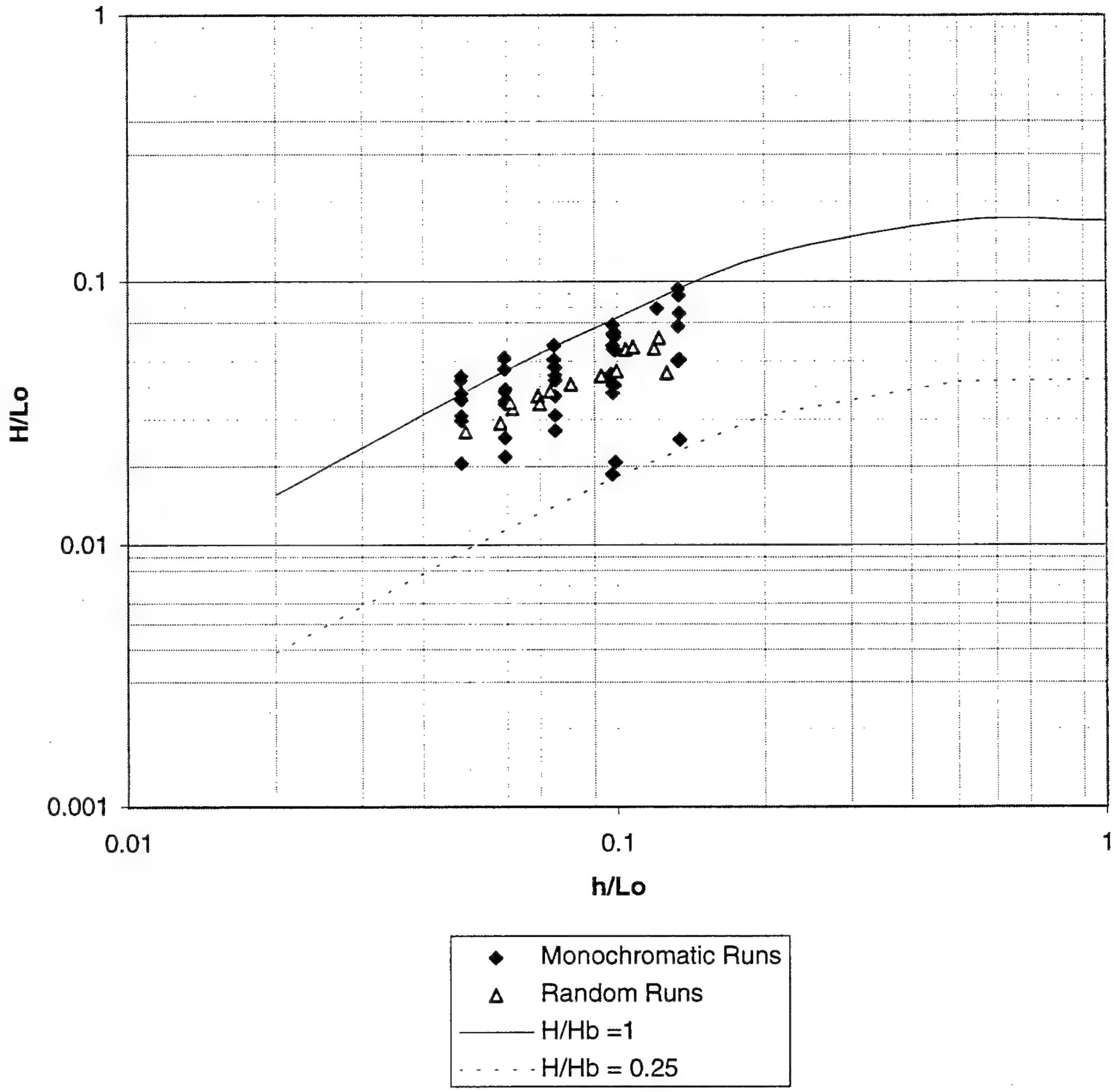

Figure 5.9 Wave Steepness Versus Relative Water Depth at the Shallow Model Center

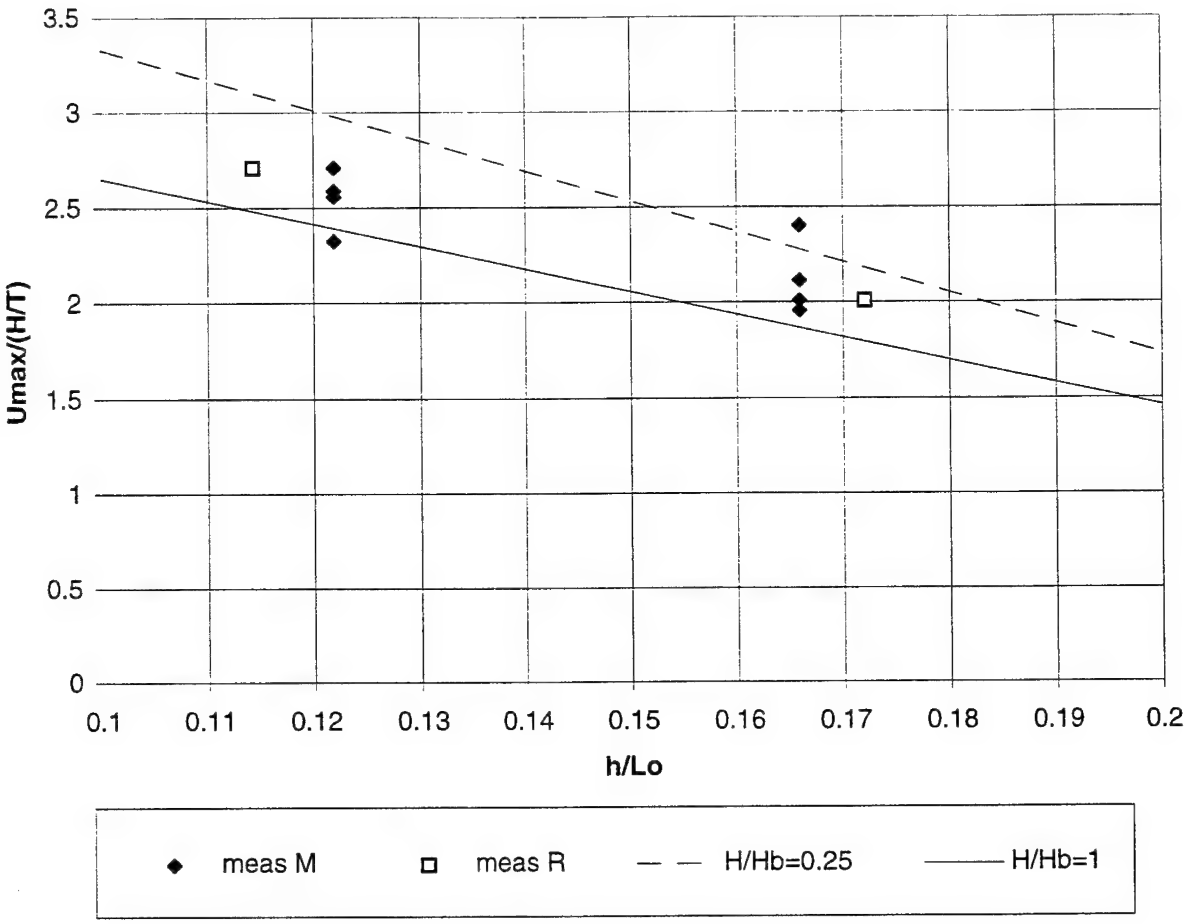

Figure 5.10
Maximum Dimensionless Horizontal Velocities at Deeper Model with Dean's Theoretical Velocities Versus Relative Water Depth, S/h=0.235

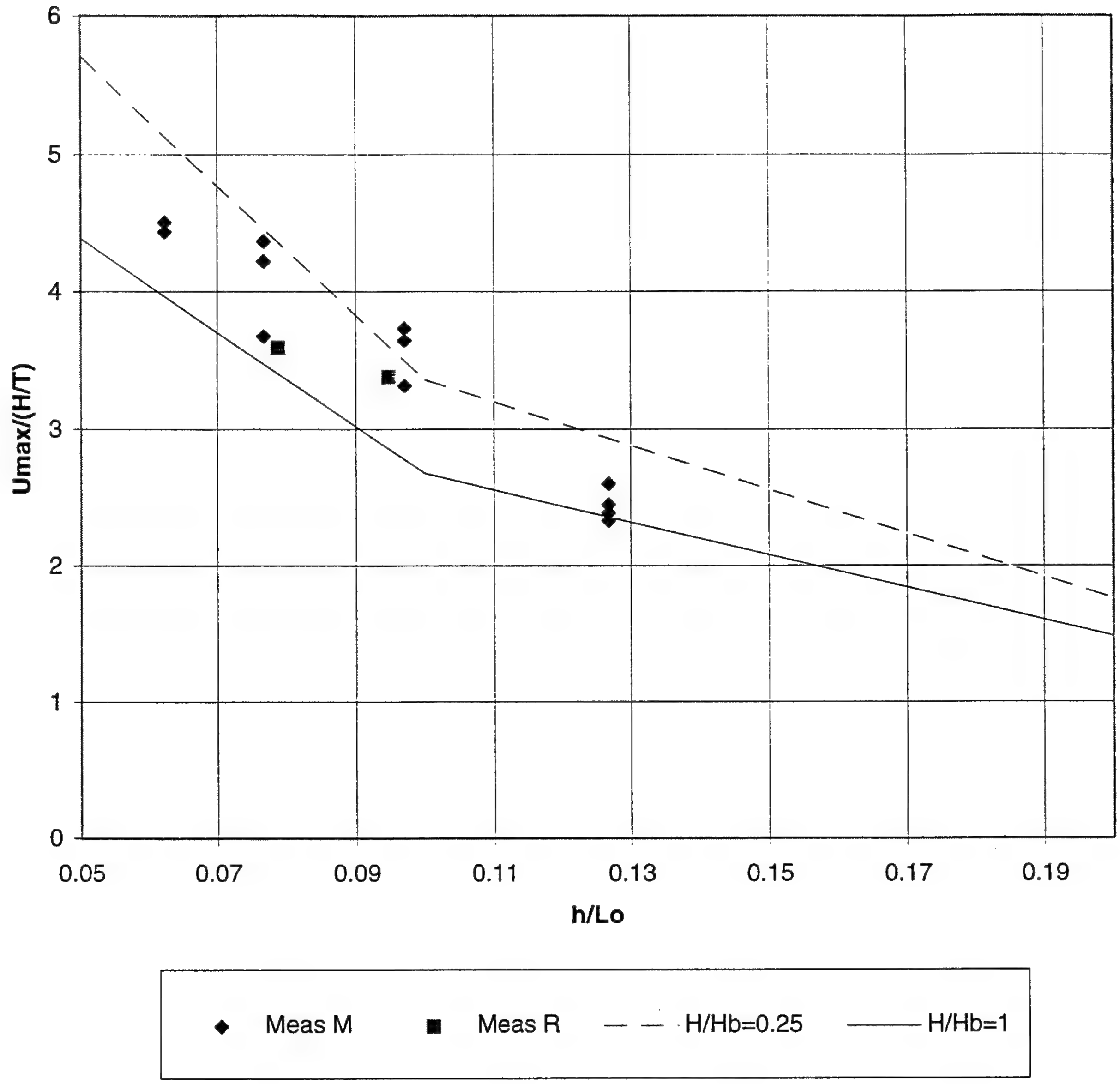

Figure 5.11 Maximum Dimensionless Horizontal Velocities at Deep Model with Dean's Theoretical Velocities Versus Relative Water Depth, S/h=0.271

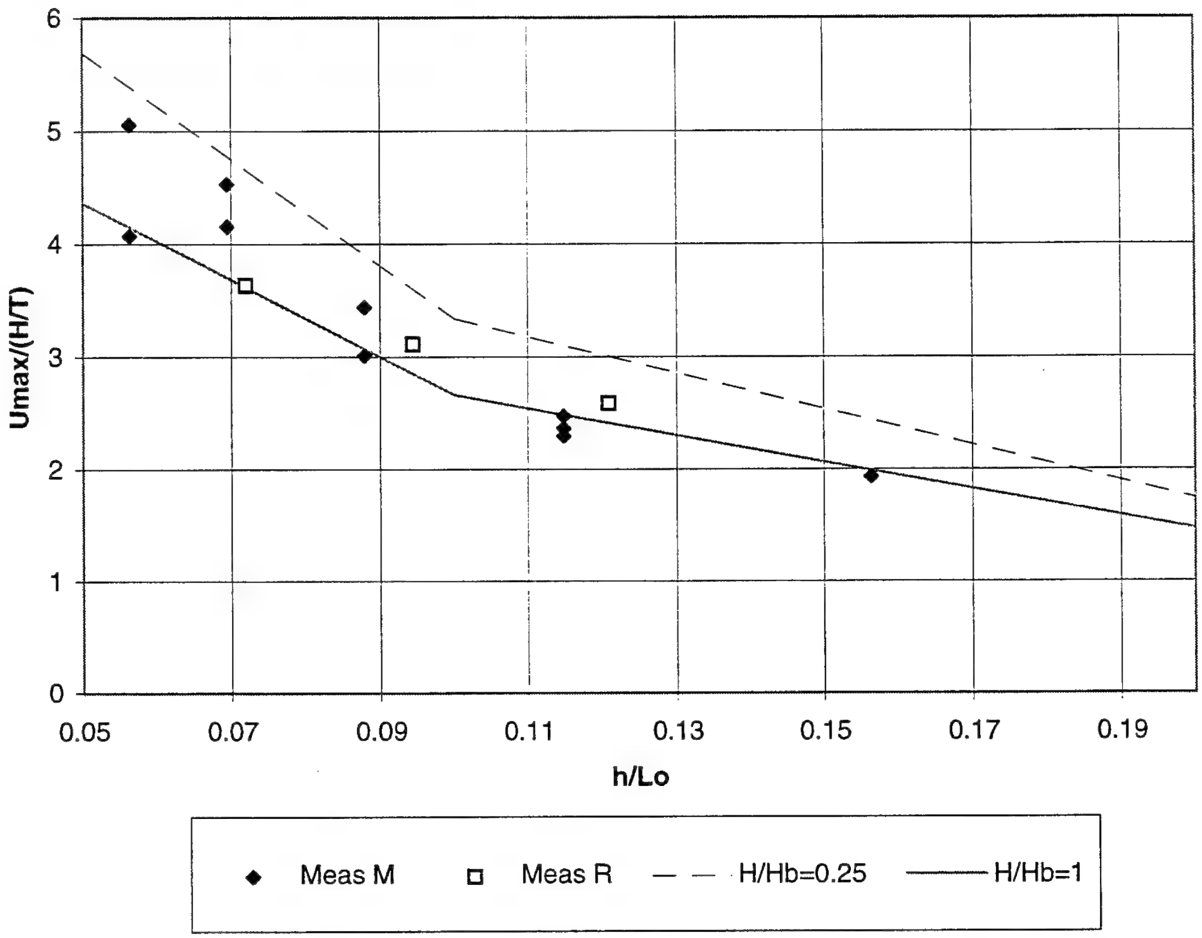

Figure 5.12 Maximum Dimensionless Horizontal Velocities at Shallow Model with Dean's Theoretical Velocities Versus Relative Water Depth, S/h=0.246

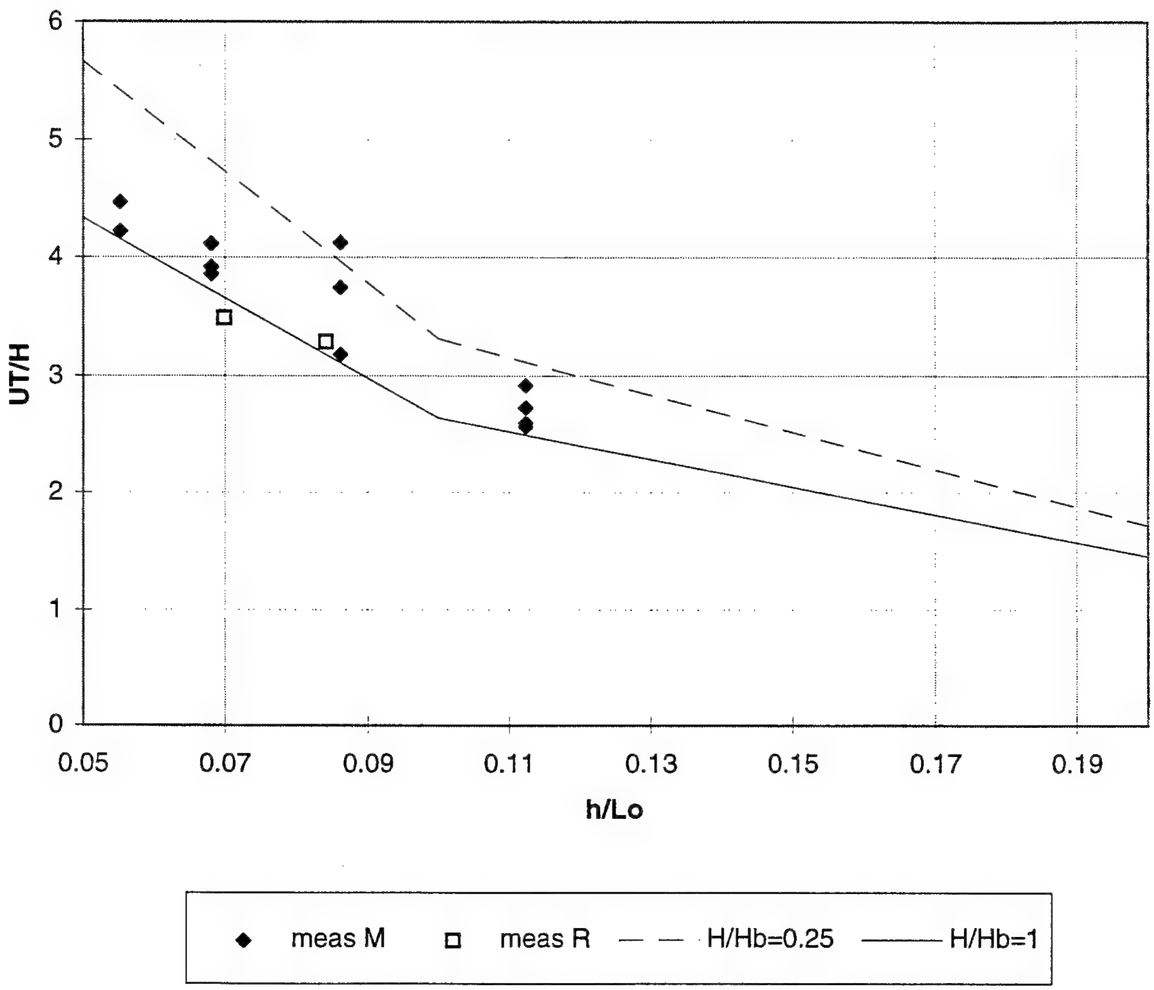

Figure 5.13
Maximum Dimensionless Horizontal Velocities at Shallow Model with Dean's Theoretical Velocites versus relative water depth, S/h=0.215.

6.0 Summary and Conclusions

6.1 Test Summary

This report summarizes the results of 65 laboratory tests conducted to determine the stability of an armor mound reballast design for Point Loma sewer outfall. Tests were conducted at Oregon State University's O.H. Hinsdale Wave Research Laboratory in Corvallis, Oregon between February 14 and February 22, 1996. Phase A of testing utilized a 1:24 scale model tested at three scale ratios simulating prototype armor stones from D_{50}=20 in. to D_{50}=28 in. Phase B of testing utilized a slightly different mound design with a 1:33.6 scale model. It was tested only at one scale ratio where D_{50}=28 in. and simulated only 692 feet of the prototype outfall length rather than the 960 feet of prototype outfall length tested in Phase A. Model rock was obtained from local quarries to reproduce the size distributions of the prototype outfall design. The model rock used in Phase A was also used in Phase B.

The false bottom of the wave channel was constructed to mimic the outfall slope at Point Loma. Model was placed in the channel such that station 67+15 was at the centerline of the shallow model at a prototype depth of 98 feet. Monochromatic tests were conducted with prototype wave periods of 12, 14, 16, 18 and 20 seconds and prototype wave heights ranging from 19 to 85 feet. For random tests spectral peak periods ranged from 12 to 20 seconds with significant wave heights varying between 35 feet to 56 feet.

Wave data were recorded via five resistive wave gauges and two acoustic current meters. Underwater video cameras recorded armor rock motion during each test run. Test conditions were presented in tabular form at model and prototype scales. Waves at the model were

considered to be incident waves, with no reflection coefficient, and were quantified in terms of peak period, zero moment wave height, and horizontal current velocities at the pipe crown.

Surveys of the two model profiles were obtained periodically throughout the testing. These measurements consisted of eleven elevations obtained at three transects on each model.

6.2 Results Summary

The original Point Loma reballast design (A Design) was found to be unstable in wave heights greater than 60 feet with periods of 14, 16, and 18 seconds unless the median rock diameter was 28 in. A revised design (B design) placed the armor material slightly lower on the pipe perimeter than the A design.

Twenty monochromatic wave conditions and eight random wave conditions were tested against the B design. Minor rock motion (less than 20 armor stones displaced) was observed with waves of 40 and 60 foot heights and periods of 12 and 14 seconds. However, these observations were early in the Phase B testing before the mound had experienced any appreciable consolidation. For random waves where $H_{1/3}$ = 70 feet, (at spectral peak periods of 12, 14, 16, 18 & 20 seconds) the rock was observed to be stable unless a wave was breaking over the shallow model which caused singular rock motion events.

The maximum measured horizontal velocities (U_{max}) in a test series usually resulted in visual damage to the armor mound (as monitored by the underwater video cameras). Runs A2412001 through A2414010 experienced armor stone damage when U_{max} > 2.0 ft/sec but no armor motion was observed for runs with smaller measured velocities. Runs A2914011 through A2916024 had armor rock motion when U_{max} > 2.5 ft/sec except in the case where the prototype period was 20 seconds. Measured horizontal velocities up to 3.3 ft/sec. did not cause armor

motion for the 20 second prototype wave period for the 1:28.8 scale tests. Runs A3414025 through B3412065 experienced armor damage through a wide range of measured horizontal velocities. Values taken from Table 5.6 are shown in Table 6.1 for the measured U_{max} at the shallow model for runs during the 1:33.6 scale test series. It should be noted only monochromatic wave conditions and the corresponding unstable armor stone observations are included in Table 6.1.

Table 6.1 Observed Armor Damage Events and Measured Horizontal Velocities

run number	prototype wave period (seconds)	U_{max} at Shallow Model Pipe (ft/sec)
A3416030	16	2.432
A3420037	20	3.025
A3414038	14	1.296
B3412043	12	1.744
B3414054	14	2.02
B3416055	16	2.349
B3416060	16	2.489

In the 1:33.6 scale test series, several runs where the prototype wave period was either 18 or 20 seconds had greater measured U_{max} values than are shown in Table 6.1 but resulted in no observable armor motion.

The only significant armor motion (20 or more stones displaced) observed in the B Model testing was leeward side erosion near the structure's toe when 70 foot 16 second waves were breaking directly on the model. This occurred during a monochromatic test, a condition that would be an extremely rare event in the ocean.

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Appendix - Record of all processed data for monochromatic waves

a2412001 T=12 H=20 WRL_STAT ver 3.0
Date processed 4- 9-96 11:40:43
Data collection date 14-FEB-1996 10:05:59.81

Starting point number .... = 1280

Number of waves averaged .... = 20

Water depth at test section ..... = 4.14 Feet

WaveMaker Period .... = 2.4500

Wave height ..(Ch# 3)............ = .803 Feet

Wavelength .... = 24.79 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.451	.000	.377	-.326	.352	-330.98	5.9200
2	Wave Ht 2	2.451	.004	.535	-.424	.480	-169.16	3.7400
3	Wave Ht 3	2.453	-.015	.438	-.366	.402	.00	3.7700
4	Wave Ht 4	2.451	-.030	.429	-.348	.388	-268.07	3.7300
5	Wave Ht 5	2.453	-.038	.529	-.388	.459	-178.83	6.5100
6	Vel 1x +N	2.449	-.077	.827	-.799	.813	-228.57	10.0000
7	Vel 1y +Up	2.451	-.040	.200	-.199	.199	-289.61	10.0000
8	Vel 2x +N	2.451	-.058	.785	-.685	.735	-342.49	10.0000
9	Vel 2y +Up	2.439	.007	.072	-.087	.080	-368.33	10.0000

a2412002 T=12 H=40 WRL_STAT ver 3.0
Date processed 4- 9-96 11:40:50
Data collection date 14-FEB-1996 10:19:59.81

Starting point number .... = 1280

Number of waves averaged .... = 20

Water depth at test section ..... = 4.14 Feet

WaveMaker Period .... = 2.4500

Wave height ..(Ch# 3)............ = 1.573 Feet

Wavelength .... = 24.84 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.451	-.008	.763	-.565	.664	-332.45	5.9200
2	Wave Ht 2	2.453	.013	1.209	-.735	.972	-177.61	3.7400
3	Wave Ht 3	2.456	-.125	.971	-.602	.786	.00	3.7700
4	Wave Ht 4	2.453	-.043	.954	-.612	.783	-273.50	3.7300
5	Wave Ht 5	2.454	-.036	1.133	-.674	.903	-197.77	6.5100
6	Vel 1x +N	2.453	-.240	1.554	-1.441	1.497	-227.27	10.0000
7	Vel 1y +Up	2.447	-.053	.406	-.354	.380	-296.89	10.0000
8	Vel 2x +N	2.453	-.193	1.470	-1.295	1.382	1.71	10.0000
9	Vel 2y +Up	2.468	-.042	.214	-.162	.188	-27.95	10.0000

a2412003 T=12 H=60 WRL_STAT ver 3.0
Date processed 4- 9-96 11:40:58
Data collection date 14-FEB-1996 10:32:59.80

Starting point number .... = 1280

Number of waves averaged .... = 20

Water depth at test section ..... = 4.14 Feet

WaveMaker Period .... = 2.4500

Wave height ..(Ch# 3)............ = 2.426 Feet

Wavelength .... = 24.79 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.451	-.182	1.126	-.690	.908	45.29	5.9200
2	Wave Ht 2	2.447	-.050	1.804	-1.043	1.424	-161.56	3.7400
3	Wave Ht 3	2.453	-.108	1.619	-.806	1.213	.00	3.7700
4	Wave Ht 4	2.453	-.103	1.597	-.739	1.168	83.18	3.7300
5	Wave Ht 5	2.456	-.077	1.862	-.849	1.355	-192.99	6.5100
6	Vel 1x +N	2.453	-.208	2.334	-1.995	2.165	-207.94	10.0000
7	Vel 1y +Up	2.451	-.071	.532	-.466	.499	78.58	10.0000
8	Vel 2x +N	2.449	-.233	2.122	-1.738	1.930	12.74	10.0000
9	Vel 2y +Up	2.468	-.019	.440	-.225	.332	-31.60	10.0000

```
a2414005 T=14  H=20                WRL_STAT  ver 3.0
 Date processed .................    4-10-96   13:59:59
 Data collection date ...........  14-FEB-1996 11:27:59.90

 Starting point number ........... = 1280

 Number of waves averaged ........ =   20

 Water depth at test section ..... =  4.14    Feet

 WaveMaker Period ................ = 2.8580

 Wave height ..(Ch# 3)............ =   .768    Feet

 Wavelength ...................... =  30.17    Feet
```

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.860	.028	.411	-.342	.377	81.62	5.9200
2 Wave Ht 2	2.856	.004	.508	-.418	.463	222.05	3.7400
3 Wave Ht 3	2.854	-.006	.430	-.338	.384	.00	3.7700
4 Wave Ht 4	2.856	.005	.477	-.388	.432	66.17	3.7300
5 Wave Ht 5	2.856	.010	.424	-.315	.369	138.44	6.5100
6 Vel 1x +N	2.858	-.069	.905	-.870	.888	170.48	10.0000
7 Vel 1y +Up	2.856	-.072	.160	-.156	.158	111.97	10.0000
8 Vel 2x +N	2.856	-.067	.861	-.761	.811	5.46	10.0000
9 Vel 2y +Up	2.861	.002	.142	-.111	.126	30.19	10.0000

```
a2414006 T=14  H=40                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96   11:41:12
 Data collection date ...........  14-FEB-1996 11:35:59.77

 Starting point number ........... = 1024

 Number of waves averaged ........ =   20

 Water depth at test section ..... =  4.14    Feet

 WaveMaker Period ................ = 2.8580

 Wave height ..(Ch# 3)............ =  1.669    Feet

 Wavelength ...................... =  30.24    Feet
```

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.856	-.123	.799	-.520	.659	89.28	5.9200
2 Wave Ht 2	2.853	.019	1.079	-.767	.923	220.22	3.7400
3 Wave Ht 3	2.860	-.015	1.062	-.607	.835	.00	3.7700
4 Wave Ht 4	2.861	-.005	1.065	-.642	.853	75.70	3.7300
5 Wave Ht 5	2.860	-.032	1.017	-.583	.800	143.93	6.5100
6 Vel 1x +N	2.858	-.175	1.750	-1.562	1.656	178.45	10.0000
7 Vel 1y +Up	2.851	-.028	.347	-.322	.335	107.97	10.0000
8 Vel 2x +N	2.860	-.167	1.647	-1.355	1.501	6.08	10.0000
9 Vel 2y +Up	2.856	-.046	.242	-.155	.198	-29.62	10.0000

```
a2414007 T=14  H=60                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96   11:41:20
 Data collection date ...........  14-FEB-1996 11:44:59.68

 Starting point number ........... = 1024

 Number of waves averaged ........ =   20

 Water depth at test section ..... =  4.14    Feet

 WaveMaker Period ................ = 2.8580

 Wave height ..(Ch# 3)............ =  2.607    Feet

 Wavelength ...................... =  30.26    Feet
```

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.860	-.142	1.432	-.733	1.082	94.84	5.9200
2 Wave Ht 2	2.860	-.017	1.895	-.951	1.423	220.52	3.7400
3 Wave Ht 3	2.861	-.050	1.790	-.817	1.303	.00	3.7700
4 Wave Ht 4	2.860	-.057	1.771	-.821	1.296	61.06	3.7300
5 Wave Ht 5	2.863	-.095	1.830	-.779	1.305	131.81	6.5100
6 Vel 1x +N	2.860	-.114	2.577	-2.023	2.300	181.28	10.0000
7 Vel 1y +Up	2.854	-.144	.506	-.399	.452	116.66	10.0000
8 Vel 2x +N	2.865	-.211	2.329	-1.789	2.059	3.98	10.0000
9 Vel 2y +Up	2.858	-.026	.445	-.205	.325	306.10	10.0000

```
a2414008 T=14  H=70                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96    11:41:27
 Data collection date ...........  14-FEB-1996 11:55:59.95

 Starting point number .......... = 1024

 Number of waves averaged ........ =   20

 Water depth at test section ..... =  4.14    Feet

 WaveMaker Period ................ = 2.8580

 Wave height ..(Ch# 3)............ =  2.842    Feet

 Wavelength ...................... =  26.60    Feet
```

Transducer Position		Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.584	-.154	1.624	-.777	1.200	72.44	5.9200
2	Wave Ht 2	2.584	-.092	2.237	-.884	1.560	212.68	3.7400
3	Wave Ht 3	2.586	-.111	2.060	-.782	1.421	.00	3.7700
4	Wave Ht 4	2.589	-.121	1.866	-.848	1.357	68.12	3.7300
5	Wave Ht 5	2.584	-.095	1.970	-.814	1.392	139.54	6.5100
6	Vel 1x +N	2.588	-.241	2.537	-1.970	2.253	172.04	10.0000
7	Vel 1y +Up	2.586	-.035	.622	-.523	.572	107.43	10.0000
8	Vel 2x +N	2.593	-.326	2.361	-1.903	2.132	11.57	10.0000
9	Vel 2y +Up	2.584	-.020	.477	-.239	.358	-43.19	10.0000

```
a2414009 T=14  H=80                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96    11:41:35
 Data collection date ...........  14-FEB-1996 12:08:59.75

 Starting point number .......... = 1024

 Number of waves averaged ........ =   20

 Water depth at test section ..... =  4.14    Feet

 WaveMaker Period ................ = 2.8580

 Wave height ..(Ch# 3)............ =  2.692    Feet

 Wavelength ...................... =  30.31    Feet
```

Transducer Position		Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.861	-.167	1.949	-.808	1.379	-236.95	5.9200
2	Wave Ht 2	2.860	-.055	2.395	-.979	1.687	-124.21	3.7400
3	Wave Ht 3	2.865	-.082	1.935	-.757	1.346	.00	3.7700
4	Wave Ht 4	2.856	-.103	1.641	-.667	1.154	-304.82	3.7300
5	Wave Ht 5	2.875	-.091	1.431	-.718	1.075	-246.22	6.5100
6	Vel 1x +N	2.854	-.248	3.020	-2.254	2.637	-153.03	10.0000
7	Vel 1y +Up	2.858	-.040	.556	-.473	.514	-211.62	10.0000
8	Vel 2x +N	2.863	-.493	2.570	-1.812	2.191	7.13	10.0000
9	Vel 2y +Up	2.865	-.048	.620	-.376	.498	-29.53	10.0000

```
a2914011 T=14  H=20                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96    11:41:43
 Data collection date ...........  14-FEB-1996 15:10:59.97

 Starting point number .......... = 1024

 Number of waves averaged ........ =   20

 Water depth at test section ..... =  3.42    Feet

 WaveMaker Period ................ = 2.6090

 Wave height ..(Ch# 3)............ =   .692    Feet

 Wavelength ...................... =  25.17    Feet
```

Transducer Position		Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.611	-.009	.333	-.282	.307	-325.91	5.9200
2	Wave Ht 2	2.609	.003	.450	-.368	.409	-168.82	3.7400
3	Wave Ht 3	2.605	-.005	.391	-.301	.346	.00	3.7700
4	Wave Ht 4	2.616	-.008	.366	-.286	.326	-262.64	3.7300
5	Wave Ht 5	2.614	-.001	.431	-.336	.384	-186.61	6.5100
6	Vel 1x +N	2.609	-.057	.767	-.725	.746	-227.00	10.0000
7	Vel 1y +Up	2.607	-.027	.197	-.202	.200	-282.39	10.0000
8	Vel 2x +N	2.611	-.047	.680	-.619	.650	16.78	10.0000
9	Vel 2y +Up	2.611	-.010	.075	-.082	.079	-31.95	10.0000

a2914012 T=14 H=40 WRL_STAT ver 3.0
Date processed 4- 9-96 11:41:50
Data collection date 14-FEB-1996 15:18:00.23

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 2.6090

Wave height ..(Ch# 3)............ = 1.326 Feet

Wavelength .... = 25.23 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.609	-.050	.666	-.504	.585	40.48	5.9200
2	Wave Ht 2	2.609	-.015	.958	-.622	.790	-170.20	3.7400
3	Wave Ht 3	2.611	-.039	.845	-.481	.663	.00	3.7700
4	Wave Ht 4	2.611	-.038	.825	-.500	.662	-271.21	3.7300
5	Wave Ht 5	2.612	-.031	.948	-.572	.760	-195.69	6.5100
6	Vel 1x +N	2.611	-.168	1.445	-1.300	1.373	-220.65	10.0000
7	Vel 1y +Up	2.607	-.050	.392	-.339	.366	-288.38	10.0000
8	Vel 2x +N	2.614	-.127	1.482	-1.189	1.336	10.79	10.0000
9	Vel 2y +Up	2.603	-.038	.198	-.140	.169	-46.09	10.0000

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a2914013 T=14 H=60 WRL_STAT ver 3.0
Date processed 4- 9-96 11:41:58
Data collection date 14-FEB-1996 15:25:59.84

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 2.6090

Wave height ..(Ch# 3)............ = 2.007 Feet

Wavelength .... = 25.25 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.611	-.103	1.071	-.698	.885	56.08	5.9200
2	Wave Ht 2	2.609	-.032	1.470	-.841	1.155	-158.93	3.7400
3	Wave Ht 3	2.612	-.064	1.426	-.581	1.003	.00	3.7700
4	Wave Ht 4	2.609	-.086	1.418	-.583	1.001	-278.29	3.7300
5	Wave Ht 5	2.609	-.068	1.625	-.685	1.155	-197.33	6.5100
6	Vel 1x +N	2.611	-.202	2.301	-1.879	2.090	-209.38	10.0000
7	Vel 1y +Up	2.612	-.100	.513	-.453	.483	-275.85	10.0000
8	Vel 2x +N	2.607	-.094	2.098	-1.513	1.806	16.57	10.0000
9	Vel 2y +Up	2.605	-.020	.375	-.203	.289	-45.37	10.0000

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a2914014 T=14 H=70 WRL_STAT ver 3.0
Date processed 4- 9-96 11:42: 5
Data collection date 14-FEB-1996 16:07:00.17

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 2.6090

Wave height ..(Ch# 3)............ = 2.414 Feet

Wavelength .... = 25.23 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.611	-.142	1.489	-.666	1.078	65.04	5.9200
2	Wave Ht 2	2.611	-.058	2.038	-.798	1.418	-147.56	3.7400
3	Wave Ht 3	2.611	-.088	1.793	-.621	1.207	.00	3.7700
4	Wave Ht 4	2.607	-.118	1.503	-.711	1.107	76.41	3.7300
5	Wave Ht 5	2.616	-.085	1.807	-.774	1.290	-210.34	6.5100
6	Vel 1x +N	2.612	-.121	2.535	-1.817	2.176	-198.22	10.0000
7	Vel 1y +Up	2.609	.047	.547	-.465	.506	99.59	10.0000
8	Vel 2x +N	2.612	-.148	2.401	-1.662	2.031	13.32	10.0000
9	Vel 2y +Up	2.605	-.016	.440	-.219	.330	-38.69	10.0000

a2920015 T=20 H=70 WRL_STAT ver 3.0
Date processed 4- 9-96 11:42:12
Data collection date 14-FEB-1996 16:36:00.04

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 3.7200

Wave height ..(Ch# 3)............ = 2.437 Feet

Wavelength .... = 38.09 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.725	-.113	1.247	-.519	.883	158.68	5.9200
2	Wave Ht 2	3.726	-.047	1.770	-.683	1.226	-102.57	3.7400
3	Wave Ht 3	3.726	-.047	1.713	-.724	1.218	.00	3.7700
4	Wave Ht 4	3.723	-.049	1.862	-.662	1.262	46.74	3.7300
5	Wave Ht 5	3.726	-.074	1.700	-.613	1.157	100.31	6.5100
6	Vel 1x +N	3.726	-.162	2.967	-1.700	2.333	-131.87	10.0000
7	Vel 1y +Up	3.721	-.071	.489	-.344	.416	-187.85	10.0000
8	Vel 2x +N	3.726	-.129	2.925	-1.614	2.269	7.73	10.0000
9	Vel 2y +Up	3.723	-.008	.490	-.200	.345	-43.84	10.0000

a2920016 T=20 H=80 WRL_STAT ver 3.0
Date processed 4- 9-96 11:42:21
Data collection date 14-FEB-1996 16:47:00.16

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 3.7200

Wave height ..(Ch# 3)............ = 2.902 Feet

Wavelength .... = 38.09 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.723	-.150	1.416	-.594	1.005	162.94	5.9200
2	Wave Ht 2	3.726	-.059	2.071	-.688	1.379	-100.96	3.7400
3	Wave Ht 3	3.726	-.057	2.106	-.796	1.451	.00	3.7700
4	Wave Ht 4	3.730	-.051	2.296	-.719	1.507	49.22	3.7300
5	Wave Ht 5	3.730	-.085	2.022	-.650	1.336	98.77	6.5100
6	Vel 1x +N	3.723	-.160	3.286	-1.692	2.489	-128.77	10.0000
7	Vel 1y +Up	3.725	-.074	.522	-.415	.468	-183.97	10.0000
8	Vel 2x +N	3.728	-.116	3.291	-1.666	2.478	5.79	10.0000
9	Vel 2y +Up	3.721	-.026	.545	-.231	.388	-42.73	10.0000

a2918017 T=18 H=40 WRL_STAT ver 3.0
Date processed 4- 9-96 11:42:28
Data collection date 15-FEB-1996 10:41:00.22

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 3.3540

Wave height ..(Ch# 3)............ = 1.347 Feet

Wavelength .... = 33.96 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.349	.007	.657	-.442	.549	125.05	5.9200
2	Wave Ht 2	3.353	.021	.817	-.468	.643	236.59	3.7400
3	Wave Ht 3	3.356	.012	.893	-.454	.674	.00	3.7700
4	Wave Ht 4	3.354	.033	.863	-.391	.627	59.38	3.7300
5	Wave Ht 5	3.354	.013	.944	-.453	.699	124.49	6.5100
6	Vel 1x +N	3.358	-.108	1.615	-1.257	1.436	203.52	10.0000
7	Vel 1y +Up	3.353	-.035	.302	-.261	.282	132.79	10.0000
8	Vel 2x +N	3.353	-.104	1.574	-1.108	1.341	3.22	10.0000
9	Vel 2y +Up	3.353	-.027	.250	-.126	.188	311.58	10.0000

a2918018 T=18 H=60 WRL_STAT ver 3.0
Date processed 4- 9-96 11:42:36
Data collection date 15-FEB-1996 10:48:59.96

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 3.3540

Wave height ..(Ch# 3)............ = 2.048 Feet

Wavelength .... = 33.92 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.354	-.065	1.108	-.565	.837	136.12	5.9200
2	Wave Ht 2	3.356	-.026	1.370	-.628	.999	251.72	3.7400
3	Wave Ht 3	3.353	-.028	1.420	-.628	1.024	.00	3.7700
4	Wave Ht 4	3.351	-.063	1.461	-.575	1.018	58.37	3.7300
5	Wave Ht 5	3.354	-.050	1.570	-.601	1.085	117.88	6.5100
6	Vel 1x +N	3.356	-.081	2.599	-1.790	2.195	216.14	10.0000
7	Vel 1y +Up	3.347	-.051	.436	-.391	.414	150.75	10.0000
8	Vel 2x +N	3.349	-.081	2.512	-1.614	2.063	11.47	10.0000
9	Vel 2y +Up	3.354	-.024	.417	-.184	.301	314.63	10.0000

a2918019 T=18 H=80 WRL_STAT ver 3.0
Date processed 4- 9-96 11:42:44
Data collection date 15-FEB-1996 10:56:00.53

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 3.3540

Wave height ..(Ch# 3)............ = 2.463 Feet

Wavelength .... = 33.94 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.354	-.141	1.754	-.502	1.128	-207.49	5.9200
2	Wave Ht 2	3.356	-.055	2.143	-.662	1.402	-104.23	3.7400
3	Wave Ht 3	3.354	-.053	1.787	-.676	1.231	.00	3.7700
4	Wave Ht 4	3.346	-.082	1.613	-.641	1.127	-307.39	3.7300
5	Wave Ht 5	3.349	-.071	1.405	-.700	1.052	-255.47	6.5100
6	Vel 1x +N	3.358	-.299	3.071	-1.639	2.355	-129.37	10.0000
7	Vel 1y +Up	3.356	-.121	.561	-.450	.505	-179.67	10.0000
8	Vel 2x +N	3.353	-.346	2.833	-1.642	2.237	-347.19	10.0000
9	Vel 2y +Up	3.353	.001	.588	-.257	.423	-25.05	10.0000

a2916021 T=16 H=40 WRL_STAT ver 3.0
Date processed 4- 9-96 11:42:52
Data collection date 15-FEB-1996 11:32:59.80

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 2.9810

Wave height ..(Ch# 3)............ = 1.226 Feet

Wavelength .... = 29.63 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.979	-.023	.792	-.543	.668	83.39	5.9200
2	Wave Ht 2	2.982	-.008	.900	-.513	.707	-136.80	3.7400
3	Wave Ht 3	2.981	-.025	.813	-.412	.613	.00	3.7700
4	Wave Ht 4	2.981	-.014	.879	-.544	.712	69.65	3.7300
5	Wave Ht 5	2.981	-.023	.850	-.456	.653	138.09	6.5100
6	Vel 1x +N	2.986	-.126	1.727	-1.418	1.572	178.84	10.0000
7	Vel 1y +Up	2.979	-.072	.301	-.247	.274	116.01	10.0000
8	Vel 2x +N	2.984	-.137	1.696	-1.386	1.541	10.86	10.0000
9	Vel 2y +Up	2.977	-.020	.299	-.152	.226	-50.79	10.0000

a2916022 T=16 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:43: 0

Data collection date 15-FEB-1996 11:40:00.04

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 2.9810

Wave height ..(Ch# 3)............ = 2.033 Feet

Wavelength .... = 29.61 Feet

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.982	-.074	1.216	-.678	.947	94.96	5.9200
2 Wave Ht 2	2.975	-.034	1.373	-.723	1.048	-138.94	3.7400
3 Wave Ht 3	2.979	-.056	1.486	-.547	1.016	.00	3.7700
4 Wave Ht 4	2.981	-.048	1.557	-.604	1.081	62.40	3.7300
5 Wave Ht 5	2.984	-.059	1.671	-.567	1.119	135.11	6.5100
6 Vel 1x +N	2.981	-.140	2.624	-2.055	2.340	184.39	10.0000
7 Vel 1y +Up	2.982	-.118	.492	-.385	.438	118.90	10.0000
8 Vel 2x +N	2.981	-.079	2.554	-1.665	2.109	8.25	10.0000
9 Vel 2y +Up	2.981	-.056	.402	-.184	.293	-46.90	10.0000

a2916023 T=16 H=80 WRL_STAT ver 3.0

Date processed 4- 9-96 11:43: 8

Data collection date 15-FEB-1996 11:47:00.01

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 3.42 Feet

WaveMaker Period .... = 2.9810

Wave height ..(Ch# 3)............ = 2.775 Feet

Wavelength .... = 29.69 Feet

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.981	-.146	1.729	-.739	1.234	115.74	5.9200
2 Wave Ht 2	2.984	-.070	2.041	-.797	1.419	236.24	3.7400
3 Wave Ht 3	2.986	-.077	2.137	-.638	1.388	.00	3.7700
4 Wave Ht 4	2.988	-.080	1.964	-.671	1.317	59.84	3.7300
5 Wave Ht 5	2.982	-.090	1.673	-.598	1.136	121.51	6.5100
6 Vel 1x +N	2.984	-.164	3.155	-2.142	2.648	200.46	10.0000
7 Vel 1y +Up	2.982	-.045	.534	-.467	.501	140.02	10.0000
8 Vel 2x +N	2.977	-.188	2.958	-1.779	2.369	11.08	10.0000
9 Vel 2y +Up	2.982	-.024	.440	-.249	.345	-40.03	10.0000

a3414025 T=14 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:43:16

Data collection date 15-FEB-1996 14:38:59.94

Starting point number .... = 1280

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.4150

Wave height ..(Ch# 3)............ = 2.002 Feet

Wavelength .... = 21.62 Feet

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.412	-.115	.879	-.457	.668	7.21	5.9200
2 Wave Ht 2	2.414	-.042	1.365	-.749	1.057	174.23	3.7400
3 Wave Ht 3	2.409	-.069	1.412	-.590	1.001	.00	3.7700
4 Wave Ht 4	2.412	-.070	1.358	-.515	.937	92.28	3.7300
5 Wave Ht 5	2.407	-.074	1.152	-.509	.831	185.21	6.5100
6 Vel 1x +N	2.419	-.136	2.094	-1.767	1.931	126.23	10.0000
7 Vel 1y +Up	2.418	-.043	.579	-.475	.527	49.64	10.0000
8 Vel 2x +N	2.411	.046	1.904	-1.321	1.612	12.94	10.0000
9 Vel 2y +Up	2.411	-.024	.356	-.233	.295	304.91	10.0000

a3414026 T=14 H=80 WRL_STAT ver 3.0
Date processed 4- 9-96 11:43:23
Data collection date 15-FEB-1996 16:38:59.76

Starting point number .... = 1280

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.4150

Wave height ..(Ch# 3)............ = 1.770 Feet

Wavelength .... = 21.86 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.416	-.161	1.180	-.596	.888	35.76	5.9200
2	Wave Ht 2	2.421	-.054	1.702	-.704	1.203	-158.86	3.7400
3	Wave Ht 3	2.430	-.084	1.198	-.572	.885	.00	3.7700
4	Wave Ht 4	2.430	-.081	.879	-.441	.660	86.92	3.7300
5	Wave Ht 5	2.425	-.069	.731	-.434	.583	-189.31	6.5100
6	Vel 1x +N	2.419	-.168	2.433	-1.844	2.138	-201.88	10.0000
7	Vel 1y +Up	2.411	-.041	.666	-.467	.566	-265.09	10.0000
8	Vel 2x +N	2.425	-.223	1.816	-1.317	1.567	23.76	10.0000
9	Vel 2y +Up	2.539	.026	.408	-.328	.368	55.54	10.0000

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a3414027 T=14 H=70 WRL_STAT ver 3.0
Date processed 4- 9-96 11:43:31
Data collection date 15-FEB-1996 16:49:59.87

Starting point number .... = 1280

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.4150

Wave height ..(Ch# 3)............ = 2.148 Feet

Wavelength .... = 21.66 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.416	-.124	1.083	-.544	.814	10.68	5.9200
2	Wave Ht 2	2.411	-.038	1.521	-.775	1.148	-177.22	3.7400
3	Wave Ht 3	2.412	-.076	1.494	-.654	1.074	.00	3.7700
4	Wave Ht 4	2.416	-.084	1.524	-.524	1.024	-272.46	3.7300
5	Wave Ht 5	2.418	-.082	1.416	-.473	.944	-182.42	6.5100
6	Vel 1x +N	2.416	-.133	2.419	-1.885	2.152	-228.00	10.0000
7	Vel 1y +Up	2.411	-.043	.606	-.523	.564	-299.19	10.0000
8	Vel 2x +N	2.421	-.104	2.106	-1.434	1.770	13.38	10.0000
9	Vel 2y +Up	2.409	-.014	.379	-.262	.320	-53.80	10.0000

A3416029 T=16 H=60 WRL_STAT ver 3.0
Date processed 4- 9-96 11:43:38
Data collection date 16-FEB-1996 08:46:00.77

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.7600

Wave height ..(Ch# 3)............ = 1.617 Feet

Wavelength .... = 25.47 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.760	-.083	.923	-.448	.686	61.75	5.9200
2	Wave Ht 2	2.756	-.023	1.216	-.617	.916	205.29	3.7400
3	Wave Ht 3	2.756	-.052	1.147	-.470	.808	.00	3.7700
4	Wave Ht 4	2.760	-.072	1.027	-.418	.723	83.71	3.7300
5	Wave Ht 5	2.761	-.064	1.309	-.538	.924	163.18	6.5100
6	Vel 1x +N	2.758	-.038	2.226	-1.612	1.919	157.95	10.0000
7	Vel 1y +Up	2.756	-.055	.510	-.424	.467	93.39	10.0000
8	Vel 2x +N	2.754	-.024	2.015	-1.313	1.664	11.33	10.0000
9	Vel 2y +Up	2.754	-.016	.341	-.178	.259	-39.43	10.0000

a3416030 T=16 H=80 WRL_STAT ver 3.0
Date processed 4- 9-96 11:43:46
Data collection date 16-FEB-1996 08:56:00.54

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.7600

Wave height ..(Ch# 3)............ = 2.229 Feet

Wavelength .... = 25.53 Feet

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.761	-.149	1.264	-.554	.909	80.18	5.9200
2 Wave Ht 2	2.761	-.047	1.930	-.680	1.305	213.15	3.7400
3 Wave Ht 3	2.761	-.071	1.658	-.571	1.115	.00	3.7700
4 Wave Ht 4	2.761	-.104	1.203	-.452	.827	72.79	3.7300
5 Wave Ht 5	2.767	-.073	1.487	-.560	1.024	144.00	6.5100
6 Vel 1x +N	2.758	-.146	2.766	-1.780	2.273	172.09	10.0000
7 Vel 1y +Up	2.754	-.021	.653	-.491	.572	113.06	10.0000
8 Vel 2x +N	2.761	-.018	2.432	-1.424	1.928	18.69	10.0000
9 Vel 2y +Up	2.754	.010	.407	-.219	.313	-30.93	10.0000

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a3418032 T=18 H=60 WRL_STAT ver 3.0
Date processed 4- 9-96 11:43:54
Data collection date 16-FEB-1996 09:46:00.43

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.1050

Wave height ..(Ch# 3)............ = 1.608 Feet

Wavelength .... = 29.21 Feet

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	3.105	-.069	.982	-.559	.771	-263.17	5.9200
2 Wave Ht 2	3.105	-.033	1.148	-.536	.842	-135.45	3.7400
3 Wave Ht 3	3.103	-.046	1.190	-.419	.804	.00	3.7700
4 Wave Ht 4	3.102	-.052	1.198	-.501	.849	-292.87	3.7300
5 Wave Ht 5	3.102	-.044	1.392	-.489	.940	-224.39	6.5100
6 Vel 1x +N	3.100	-.077	2.341	-1.572	1.956	-172.84	10.0000
7 Vel 1y +Up	3.102	-.069	.443	-.363	.403	-235.03	10.0000
8 Vel 2x +N	3.098	-.049	2.346	-1.484	1.915	11.62	10.0000
9 Vel 2y +Up	3.102	-.019	.365	-.144	.254	-42.75	10.0000

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a3418033 T=18 H=80 WRL_STAT ver 3.0
Date processed 4- 9-96 11:44: 1
Data collection date 16-FEB-1996 09:57:00.62

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.1050

Wave height ..(Ch# 3)............ = 2.298 Feet

Wavelength .... = 29.25 Feet

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	3.102	-.122	1.404	-.641	1.022	-250.31	5.9200
2 Wave Ht 2	3.105	-.058	1.703	-.642	1.173	-125.01	3.7400
3 Wave Ht 3	3.107	-.074	1.821	-.477	1.149	.00	3.7700
4 Wave Ht 4	3.107	-.079	1.958	-.591	1.274	61.02	3.7300
5 Wave Ht 5	3.107	-.066	2.012	-.515	1.264	-236.56	6.5100
6 Vel 1x +N	3.102	-.143	3.016	-1.901	2.458	-162.30	10.0000
7 Vel 1y +Up	3.105	-.028	.553	-.473	.513	-222.01	10.0000
8 Vel 2x +N	3.098	.045	3.071	-1.694	2.382	12.01	10.0000
9 Vel 2y +Up	3.100	-.014	.436	-.193	.314	-40.06	10.0000

a3412035 T=12 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:44: 6
Data collection date 16-FEB-1996 10:33:00.34

Starting point number .... = 1536

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.0700

Wave height ..(Ch# 3)............ = 1.876 Feet

Wavelength .... = 17.80 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.072	-.123	.993	-.623	.808	-85.14	5.9200
2	Wave Ht 2	2.072	-.037	1.263	-.610	.936	124.81	3.7400
3	Wave Ht 3	2.074	-.058	1.279	-.597	.938	.00	3.7700
4	Wave Ht 4	2.070	-.047	1.338	-.723	1.031	101.73	3.7300
5	Wave Ht 5	2.067	-.064	1.357	-.619	.988	-153.00	6.5100
6	Vel 1x +N	2.070	-.025	1.832	-1.577	1.704	50.43	10.0000
7	Vel 1y +Up	2.063	-.045	.618	-.527	.572	-16.58	10.0000
8	Vel 2x +N	2.072	-.022	1.753	-1.413	1.583	2.03	10.0000
9	Vel 2y +Up	2.072	-.032	.373	-.264	.318	-62.84	10.0000

a3420036 T=20 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:44:14
Data collection date 16-FEB-1996 10:46:00.56

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.4500

Wave height ..(Ch# 3)............ = 1.604 Feet

Wavelength .... = 32.79 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.449	-.065	.972	-.395	.684	127.34	5.9200
2	Wave Ht 2	3.451	-.017	1.294	-.542	.918	244.63	3.7400
3	Wave Ht 3	3.447	-.038	1.130	-.474	.802	.00	3.7700
4	Wave Ht 4	3.447	-.036	1.273	-.532	.903	58.83	3.7300
5	Wave Ht 5	3.447	-.051	1.212	-.485	.848	120.79	6.5100
6	Vel 1x +N	3.446	-.044	2.493	-1.436	1.964	205.83	10.0000
7	Vel 1y +Up	3.444	-.075	.435	-.303	.369	154.19	10.0000
8	Vel 2x +N	3.447	-.073	2.352	-1.357	1.855	9.57	10.0000
9	Vel 2y +Up	3.449	-.017	.416	-.170	.293	-43.66	10.0000

a3420037 T=20 H=80 WRL_STAT ver 3.0

Date processed 4- 9-96 11:44:22
Data collection date 16-FEB-1996 10:59:00.47

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.4500

Wave height ..(Ch# 3)............ = 2.566 Feet

Wavelength .... = 32.81 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.451	-.128	1.419	-.474	.947	137.88	5.9200
2	Wave Ht 2	3.451	-.047	2.061	-.604	1.332	247.42	3.7400
3	Wave Ht 3	3.449	-.060	1.966	-.600	1.283	.00	3.7700
4	Wave Ht 4	3.447	-.056	2.058	-.614	1.336	55.17	3.7300
5	Wave Ht 5	3.449	-.080	1.742	-.565	1.153	112.38	6.5100
6	Vel 1x +N	3.453	-.082	3.041	-1.459	2.250	213.58	10.0000
7	Vel 1y +Up	3.449	-.026	.594	-.405	.499	167.00	10.0000
8	Vel 2x +N	3.449	-.056	3.025	-1.442	2.234	10.44	10.0000
9	Vel 2y +Up	3.447	.003	.506	-.200	.353	-36.55	10.0000

```
b3412038 T=12  H=40                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96    11:44:29
 Data collection date ...........   21-FEB-1996 16:19:00.14

 Starting point number .......... = 1536

 Number of waves averaged ....... =   20

 Water depth at test section .... =  2.93    Feet

 WaveMaker Period ............... = 2.0700

 Wave height ..(Ch# 3)........... =  1.264    Feet

 Wavelength ..................... =  17.78    Feet
```

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.068	-.012	.752	-.533	.642	-90.21	4.4500
2 Wave Ht 2	2.070	-.034	.773	-.432	.602	-226.65	4.2600
3 Wave Ht 3	2.072	-.035	.757	-.507	.632	.00	4.1300
4 Wave Ht 4	2.070	-.005	.966	-.525	.746	-248.09	4.0800
5 Wave Ht 5	2.072	-.096	1.070	-.429	.749	-126.84	8.3100
6 Vel 1x +N	2.072	-.092	1.304	-1.157	1.231	52.70	10.0000
7 Vel 1y +Up	2.068	-.010	.472	-.391	.432	-19.44	10.0000
8 Vel 2x +N	2.070	-.081	1.296	-1.171	1.234	26.08	10.0000
9 Vel 2y +Up	2.072	-.031	.211	-.200	.206	-43.73	10.0000

```
b3414039 T=14  H=40                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96    11:44:36
 Data collection date ...........   21-FEB-1996 16:35:00.01

 Starting point number .......... = 1280

 Number of waves averaged ....... =   20

 Water depth at test section .... =  2.93    Feet

 WaveMaker Period ............... = 2.4150

 Wave height ..(Ch# 3)........... =  1.348    Feet

 Wavelength ..................... =  21.70    Feet
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Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.414	-.021	.641	-.442	.542	-6.71	4.4500
2 Wave Ht 2	2.416	-.020	.922	-.548	.735	160.69	4.2600
3 Wave Ht 3	2.416	-.020	.869	-.479	.674	.00	4.1300
4 Wave Ht 4	2.416	-.028	.755	-.460	.607	88.67	4.0800
5 Wave Ht 5	2.416	-.037	.781	-.455	.618	179.32	8.3100
6 Vel 1x +N	2.414	-.146	1.502	-1.356	1.429	106.88	10.0000
7 Vel 1y +Up	2.418	-.046	.424	-.338	.381	33.01	10.0000
8 Vel 2x +N	2.412	-.064	1.325	-1.086	1.205	10.94	10.0000
9 Vel 2y +Up	2.414	-.038	.201	-.191	.196	300.49	10.0000

```
b3416040 T=16  H=40                WRL_STAT  ver 3.0
 Date processed .................    4- 9-96    11:44:42
 Data collection date ...........   21-FEB-1996 16:45:59.99

 Starting point number .......... = 1024

 Number of waves averaged ....... =   20

 Water depth at test section .... =  2.93    Feet

 WaveMaker Period ............... = 2.7600

 Wave height ..(Ch# 3)........... =  1.213    Feet

 Wavelength ..................... =  25.51    Feet
```

Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1 Wave Ht 1	2.761	-.014	.699	-.418	.559	49.11	4.4500
2 Wave Ht 2	2.760	-.012	.790	-.468	.629	197.63	4.2600
3 Wave Ht 3	2.760	-.014	.783	-.429	.606	.00	4.1300
4 Wave Ht 4	2.758	-.026	.692	-.370	.531	85.94	4.0800
5 Wave Ht 5	2.758	-.017	.841	-.505	.673	165.34	8.3100
6 Vel 1x +N	2.758	-.092	1.512	-1.236	1.374	147.07	10.0000
7 Vel 1y +Up	2.758	-.053	.382	-.311	.346	83.32	10.0000
8 Vel 2x +N	2.760	-.076	1.394	-1.023	1.209	18.92	10.0000
9 Vel 2y +Up	2.758	-.037	.186	-.133	.159	-33.50	10.0000

b3418041 T=18 H=40 WRL_STAT ver 3.0

Date processed 4- 9-96 11:44:51

Data collection date 21-FEB-1996 16:56:00.05

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.1050

Wave height ..(Ch# 3)............ = 1.100 Feet

Wavelength .... = 29.21 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.103	-.005	.702	-.468	.585	-269.50	4.4500
2	Wave Ht 2	3.102	-.012	.736	-.423	.580	-140.63	4.2600
3	Wave Ht 3	3.103	-.014	.756	-.344	.550	.00	4.1300
4	Wave Ht 4	3.102	-.008	.847	-.414	.630	-287.26	4.0800
5	Wave Ht 5	3.103	-.021	.836	-.375	.605	-216.72	8.3100
6	Vel 1x +N	3.105	-.114	1.638	-1.264	1.451	-177.76	10.0000
7	Vel 1y +Up	3.102	-.074	.313	-.246	.279	-242.77	10.0000
8	Vel 2x +N	3.103	-.087	1.618	-1.141	1.379	11.79	10.0000
9	Vel 2y +Up	3.102	-.040	.190	-.115	.152	-39.65	10.0000

b3420042 T=20 H=40 WRL_STAT ver 3.0

Date processed 4- 9-96 11:44:58

Data collection date 22-FEB-1996 08:40:59.92

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.4500

Wave height ..(Ch# 3)............ = 1.121 Feet

Wavelength .... = 32.79 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.451	-.025	.678	-.398	.538	120.49	4.4500
2	Wave Ht 2	3.453	-.012	.828	-.457	.642	238.77	4.2600
3	Wave Ht 3	3.447	-.019	.718	-.403	.561	.00	4.1300
4	Wave Ht 4	3.449	-.015	.791	-.456	.624	61.06	4.0800
5	Wave Ht 5	3.447	-.026	.742	-.372	.557	122.01	8.3100
6	Vel 1x +N	3.447	-.065	1.661	-1.164	1.412	197.72	10.0000
7	Vel 1y +Up	3.447	-.062	.292	-.220	.256	140.63	10.0000
8	Vel 2x +N	3.446	-.071	1.541	-1.040	1.290	7.66	10.0000
9	Vel 2y +Up	3.444	-.037	.176	-.140	.158	-46.87	10.0000

b3412043 T=12 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:45: 6

Data collection date 22-FEB-1996 08:54:00.04

Starting point number .... = 1536

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.0700

Wave height ..(Ch# 3)............ = 1.899 Feet

Wavelength .... = 17.76 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.074	-.091	1.437	-.697	1.067	-61.05	4.4500
2	Wave Ht 2	2.074	-.075	1.410	-.570	.990	144.96	4.2600
3	Wave Ht 3	2.070	-.076	1.310	-.589	.949	.00	4.1300
4	Wave Ht 4	2.068	-.085	1.268	-.672	.970	109.07	4.0800
5	Wave Ht 5	2.072	-.091	1.277	-.582	.930	-145.66	8.3100
6	Vel 1x +N	2.075	-.146	1.929	-1.613	1.771	77.48	10.0000
7	Vel 1y +Up	2.067	-.039	.632	-.508	.570	13.65	10.0000
8	Vel 2x +N	2.072	-.011	1.744	-1.331	1.537	27.51	10.0000
9	Vel 2y +Up	2.072	-.042	.329	-.223	.276	-30.41	10.0000

b3414044 T=14 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:45:13
Data collection date 22-FEB-1996 09:11:59.80

Starting point number .... = 1280

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.4150

Wave height ..(Ch# 3)............ = 2.265 Feet

Wavelength .... = 21.64 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.411	-.066	1.065	-.508	.787	-345.98	4.4500
2	Wave Ht 2	2.411	-.061	1.388	-.768	1.078	-181.70	4.2600
3	Wave Ht 3	2.411	-.051	1.580	-.685	1.132	.00	4.1300
4	Wave Ht 4	2.407	-.076	1.350	-.545	.948	-268.71	4.0800
5	Wave Ht 5	2.407	-.061	1.321	-.551	.936	-176.48	8.3100
6	Vel 1x +N	2.409	-.145	2.210	-1.834	2.022	-226.42	10.0000
7	Vel 1y +Up	2.412	-.091	.607	-.519	.563	-303.45	10.0000
8	Vel 2x +N	2.419	.015	1.899	-1.299	1.599	18.85	10.0000
9	Vel 2y +Up	2.409	-.045	.320	-.240	.280	-48.82	10.0000

b3416045 T=16 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:45:20
Data collection date 22-FEB-1996 09:27:00.22

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.7600

Wave height ..(Ch# 3)............ = 1.850 Feet

Wavelength .... = 25.47 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.761	-.046	1.219	-.499	.859	64.75	4.4500
2	Wave Ht 2	2.758	-.054	1.314	-.606	.960	207.33	4.2600
3	Wave Ht 3	2.756	-.053	1.295	-.555	.925	.00	4.1300
4	Wave Ht 4	2.760	-.071	1.239	-.493	.866	80.23	4.0800
5	Wave Ht 5	2.760	-.040	1.518	-.617	1.068	158.06	8.3100
6	Vel 1x +N	2.763	-.051	2.355	-1.651	2.003	159.60	10.0000
7	Vel 1y +Up	2.753	-.059	.544	-.455	.499	95.69	10.0000
8	Vel 2x +N	2.756	-.013	2.108	-1.348	1.728	18.29	10.0000
9	Vel 2y +Up	2.758	-.032	.317	-.179	.248	-37.85	10.0000

b3418046 T=18 H=60 WRL_STAT ver 3.0

Date processed 4- 9-96 11:45:28
Data collection date 22-FEB-1996 09:42:00.12

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.1050

Wave height ..(Ch# 3)............ = 1.707 Feet

Wavelength .... = 29.19 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.107	-.047	1.176	-.591	.884	-259.93	4.4500
2	Wave Ht 2	3.105	-.047	1.226	-.528	.877	-134.87	4.2600
3	Wave Ht 3	3.102	-.053	1.242	-.465	.853	.00	4.1300
4	Wave Ht 4	3.103	-.047	1.329	-.563	.946	-291.54	4.0800
5	Wave Ht 5	3.102	-.046	1.428	-.507	.967	-229.81	8.3100
6	Vel 1x +N	3.107	-.010	2.466	-1.656	2.061	-173.03	10.0000
7	Vel 1y +Up	3.102	-.073	.457	-.389	.423	-235.61	10.0000
8	Vel 2x +N	3.102	-.040	2.416	-1.490	1.953	10.06	10.0000
9	Vel 2y +Up	3.105	-.023	.273	-.162	.218	-44.63	10.0000

b3416055 T=16 H=70 WRL_STAT ver 3.0
Date processed 4- 9-96 11:46: 0
Data collection date 22-FEB-1996 13:59:59.80

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 2.7600

Wave height ..(Ch# 3)............ = 2.120 Feet

Wavelength .... = 25.53 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	2.758	-.043	1.356	-.548	.952	68.97	4.4500
2	Wave Ht 2	2.761	-.060	1.719	-.640	1.180	211.20	4.2600
3	Wave Ht 3	2.761	-.066	1.515	-.605	1.060	.00	4.1300
4	Wave Ht 4	2.765	-.087	1.356	-.517	.936	76.39	4.0800
5	Wave Ht 5	2.763	-.055	1.594	-.627	1.110	149.39	8.3100
6	Vel 1x +N	2.758	-.112	2.633	-1.723	2.178	164.69	10.0000
7	Vel 1y +Up	2.756	-.091	.631	-.482	.556	107.11	10.0000
8	Vel 2x +N	2.758	-.030	2.349	-1.380	1.864	17.19	10.0000
9	Vel 2y +Up	2.753	-.046	.373	-.229	.301	-34.88	10.0000

b3418056 T=18 H=70 WRL_STAT ver 3.0
Date processed 4- 9-96 11:46: 7
Data collection date 22-FEB-1996 14:18:59.92

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.1050

Wave height ..(Ch# 3)............ = 2.016 Feet

Wavelength .... = 29.25 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.102	-.064	1.434	-.613	1.023	-255.34	4.4500
2	Wave Ht 2	3.107	-.070	1.519	-.554	1.036	-130.35	4.2600
3	Wave Ht 3	3.107	-.068	1.566	-.450	1.008	.00	4.1300
4	Wave Ht 4	3.105	-.060	1.740	-.569	1.155	65.89	4.0800
5	Wave Ht 5	3.109	-.066	1.792	-.495	1.143	-229.09	8.3100
6	Vel 1x +N	3.103	-.065	2.850	-1.827	2.338	-165.49	10.0000
7	Vel 1y +Up	3.105	-.035	.514	-.460	.487	-226.84	10.0000
8	Vel 2x +N	3.102	.087	2.855	-1.579	2.217	11.61	10.0000
9	Vel 2y +Up	3.102	-.036	.345	-.185	.265	-38.30	10.0000

b3420057 T=20 H=70 WRL_STAT ver 3.0
Date processed 4- 9-96 11:46:15
Data collection date 22-FEB-1996 14:39:01.01

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.4500

Wave height ..(Ch# 3)............ = 2.103 Feet

Wavelength .... = 32.83 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.451	-.064	1.442	-.425	.934	131.10	4.4500
2	Wave Ht 2	3.451	-.038	1.850	-.571	1.210	240.81	4.2600
3	Wave Ht 3	3.451	-.066	1.543	-.561	1.052	.00	4.1300
4	Wave Ht 4	3.449	-.055	1.675	-.623	1.149	55.67	4.0800
5	Wave Ht 5	3.447	-.079	1.553	-.492	1.023	112.61	8.3100
6	Vel 1x +N	3.449	-.025	2.996	-1.539	2.268	205.97	10.0000
7	Vel 1y +Up	3.449	-.065	.554	-.402	.478	158.82	10.0000
8	Vel 2x +N	3.447	-.011	2.916	-1.364	2.140	6.61	10.0000
9	Vel 2y +Up	3.446	-.031	.345	-.196	.270	-44.75	10.0000

b3418061 T=18 H=80 WRL_STAT ver 3.0
Date processed 4- 9-96 11:46:46
Data collection date 22-FEB-1996 15:26:00.00

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.1050

Wave height ..(Ch# 3)............ = 2.369 Feet

Wavelength .... = 29.23 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.102	-.164	1.465	-.576	1.021	-245.09	4.4500
2	Wave Ht 2	3.105	-.085	1.848	-.605	1.226	-121.15	4.2600
3	Wave Ht 3	3.105	-.084	1.863	-.506	1.184	.00	4.1300
4	Wave Ht 4	3.107	-.068	1.930	-.620	1.275	61.80	4.0800
5	Wave Ht 5	3.107	-.095	1.664	-.500	1.082	-233.86	8.3100
6	Vel 1x +N	3.109	-.113	3.122	-1.935	2.528	-157.30	10.0000
7	Vel 1y +Up	3.102	-.015	.589	-.466	.528	-214.14	10.0000
8	Vel 2x +N	3.107	.107	3.112	-1.592	2.352	17.96	10.0000
9	Vel 2y +Up	3.109	-.050	.401	-.207	.304	-31.27	10.0000

b3420062 T=20 H=80 WRL_STAT ver 3.0
Date processed 4- 9-96 11:46:52
Data collection date 22-FEB-1996 15:35:00.03

Starting point number .... = 1024

Number of waves averaged .... = 20

Water depth at test section ..... = 2.93 Feet

WaveMaker Period .... = 3.4500

Wave height ..(Ch# 3)............ = 2.266 Feet

Wavelength .... = 32.79 Feet

	Transducer Position	Period (Sec)	Gage Avg Feet	Amplitudes Positive	Neg	Mean	Phase (Deg)	Calibration Slope
1	Wave Ht 1	3.449	.075	1.753	-.482	1.118	145.95	4.4500
2	Wave Ht 2	3.451	-.081	2.200	-.604	1.402	249.68	4.2600
3	Wave Ht 3	3.447	-.095	1.651	-.615	1.133	.00	4.1300
4	Wave Ht 4	3.449	-.081	1.583	-.627	1.105	53.93	4.0800
5	Wave Ht 5	3.446	-.082	1.329	-.560	.944	107.62	8.3100
6	Vel 1x +N	3.454	-.102	3.118	-1.484	2.301	221.11	10.0000
7	Vel 1y +Up	3.451	-.009	.629	-.396	.513	175.96	10.0000
8	Vel 2x +N	3.446	-.037	2.802	-1.330	2.066	17.41	10.0000
9	Vel 2y +Up	3.444	-.016	.506	-.236	.371	-26.48	10.0000

Appendix - Record of all processed data for Random waves

```
------------- a2412004 T=12  H=40  Jonswap -------------
---------------------------------------------------------  Channel  1

  Raw data time series statistics
             Mean ....... =    2.4766E-01
             Variance ... =    9.3865E-02
             Energy ..... =    9.3862E-02
Total smoothed energy .................... =     9.31019E-02
Maximum smoothed value ................... =     8.22441E-01
First moment ............................. =     4.16532E-02
Second moment ............................ =     2.08893E-02
Hmo ...................................... =     1.221

Max density =      1.24790  at X =   .42481 Hz.     2.3540 sec.
YMAX =    1.50000   Delta-Y =      .30000
---------------------------------------------------------  Channel  2

  Raw data time series statistics
             Mean ....... =    1.8008E-01
             Variance ... =    1.4838E-01
             Energy ..... =    1.4838E-01
Total smoothed energy .................... =     1.48053E-01
Maximum smoothed value ................... =     1.44358E+00
First moment ............................. =     6.65828E-02
Second moment ............................ =     3.33062E-02
Hmo ...................................... =     1.539

Max density =      1.44358  at X =   .41565 Hz.     2.4058 sec.
YMAX =    1.50000   Delta-Y =      .30000
---------------------------------------------------------  Channel  3

  Raw data time series statistics
             Mean ....... =    1.1914E-01
             Variance ... =    1.3000E-01
             Energy ..... =    1.3000E-01
Total smoothed energy .................... =     1.29676E-01
Maximum smoothed value ................... =     1.14332E+00
First moment ............................. =     5.88188E-02
Second moment ............................ =     3.01364E-02
Hmo ...................................... =     1.440

Max density =      1.24790  at X =   .42481 Hz.     2.3540 sec.
YMAX =    1.50000   Delta-Y =      .30000
---------------------------------------------------------  Channel  4

  Raw data time series statistics
             Mean ....... =    1.1398E-01
             Variance ... =    1.3776E-01
             Energy ..... =    1.3776E-01
Total smoothed energy .................... =     1.37563E-01
Maximum smoothed value ................... =     1.01454E+00
First moment ............................. =     6.23387E-02
Second moment ............................ =     3.20018E-02
Hmo ...................................... =     1.484

Max density =      1.24790  at X =   .39551 Hz.     2.5284 sec.
YMAX =    1.50000   Delta-Y =      .30000
```

```
------------- a2412004 T=12  H=40  Jonswap -------------
---------------------------------------------------------  Channel  5

  Raw data time series statistics
             Mean ....... =    9.6861E-02
             Variance ... =    1.3342E-01
             Energy ..... =    1.3341E-01
Total smoothed energy .................... =     1.33331E-01
Maximum smoothed value ................... =     1.16909E+00
First moment ............................. =     6.05146E-02
Second moment ............................ =     3.13980E-02
Hmo ...................................... =     1.461

Max density =      1.24790  at X =   .39917 Hz.     2.5052 sec.
YMAX =    1.50000   Delta-Y =      .30000
---------------------------------------------------------  Channel  6

  Raw data time series statistics
             Mean ....... =   -1.9246E-02
             Variance ... =    4.1418E-01
             Energy ..... =    4.1417E-01
Total smoothed energy .................... =     4.12775E-01
Maximum smoothed value ................... =     3.84451E+00
First moment ............................. =     1.60316E-01
Second moment ............................ =     6.62173E-02
Hmo ...................................... =     2.570

Max density =      3.84451  at X =   .41565 Hz.     2.4058 sec.
YMAX =    5.00000   Delta-Y =     1.00000
---------------------------------------------------------  Channel  8

  Raw data time series statistics
             Mean ....... =    7.0683E-03
             Variance ... =    3.6806E-01
             Energy ..... =    3.6805E-01
Total smoothed energy .................... =     3.66423E-01
Maximum smoothed value ................... =     3.36034E+00
First moment ............................. =     1.43028E-01
Second moment ............................ =     5.99061E-02
Hmo ...................................... =     2.421

Max density =      3.36034  at X =   .39551 Hz.     2.5284 sec.
YMAX =    5.00000   Delta-Y =     1.00000
```

```
------------- a2414010 T=14  H=60  Jonswap -------------
---------------------------------------------------------  Channel  1

  Raw data time series statistics
             Mean ....... =    3.9982E-01
             Variance ... =    1.9636E-01
             Energy ..... =    1.9635E-01
Total smoothed energy .................... =     1.95982E-01
Maximum smoothed value ................... =     1.79111E+00
First moment ............................. =     7.82906E-02
Second moment ............................ =     3.64421E-02
Hmo ...................................... =     1.771

Max density =      3.26260  at X =   .35523 Hz.     2.8151 sec.
YMAX =    4.00000   Delta-Y =      .80000
---------------------------------------------------------  Channel  2

  Raw data time series statistics
             Mean ....... =    2.8550E-01
             Variance ... =    2.7004E-01
             Energy ..... =    2.7003E-01
Total smoothed energy .................... =     2.69900E-01
Maximum smoothed value ................... =     2.47944E+00
First moment ............................. =     1.09174E-01
Second moment ............................ =     5.20168E-02
Hmo ...................................... =     2.078

Max density =      3.26260  at X =   .33875 Hz.     2.9520 sec.
YMAX =    4.00000   Delta-Y =      .80000
---------------------------------------------------------  Channel  3

  Raw data time series statistics
             Mean ....... =    2.3415E-01
             Variance ... =    2.4278E-01
             Energy ..... =    2.4278E-01
Total smoothed energy .................... =     2.42620E-01
Maximum smoothed value ................... =     2.33395E+00
First moment ............................. =     9.71251E-02
Second moment ............................ =     4.67945E-02
Hmo ...................................... =     1.970

Max density =      3.26260  at X =   .33875 Hz.     2.9520 sec.
YMAX =    4.00000   Delta-Y =      .80000
---------------------------------------------------------  Channel  4

  Raw data time series statistics
             Mean ....... =    2.1384E-01
             Variance ... =    2.4233E-01
             Energy ..... =    2.4233E-01
Total smoothed energy .................... =     2.42157E-01
Maximum smoothed value ................... =     2.01274E+00
First moment ............................. =     9.67300E-02
Second moment ............................ =     4.66995E-02
Hmo ...................................... =     1.968

Max density =      3.26260  at X =   .33875 Hz.     2.9520 sec.
YMAX =    4.00000   Delta-Y =      .80000
```

```
------------- a2414010 T=14  H=60  Jonswap -------------
---------------------------------------------------------  Channel  5

  Raw data time series statistics
             Mean ....... =    1.8163E-01
             Variance ... =    2.4030E-01
             Energy ..... =    2.4029E-01
Total smoothed energy .................... =     2.40072E-01
Maximum smoothed value ................... =     2.16683E+00
First moment ............................. =     9.63420E-02
Second moment ............................ =     4.67362E-02
Hmo ...................................... =     1.960

Max density =      3.26260  at X =   .33875 Hz.     2.9520 sec.
YMAX =    4.00000   Delta-Y =      .80000
---------------------------------------------------------  Channel  6

  Raw data time series statistics
             Mean ....... =   -2.9829E-02
             Variance ... =    9.1525E-01
             Energy ..... =    9.1524E-01
Total smoothed energy .................... =     9.09914E-01
Maximum smoothed value ................... =     9.10435E+00
First moment ............................. =     3.06195E-01
Second moment ............................ =     1.11777E-01
Hmo ...................................... =     3.816

Max density =      9.10435  at X =   .33875 Hz.     2.9520 sec.
YMAX =   10.00000   Delta-Y =     2.00000
---------------------------------------------------------  Channel  8

  Raw data time series statistics
             Mean ....... =   -2.0119E-02
             Variance ... =    8.0384E-01
             Energy ..... =    8.0382E-01
Total smoothed energy .................... =     7.98495E-01
Maximum smoothed value ................... =     7.83769E+00
First moment ............................. =     2.72322E-01
Second moment ............................ =     1.02497E-01
Hmo ...................................... =     3.574

Max density =      7.83769  at X =   .33875 Hz.     2.9520 sec.
YMAX =   10.00000   Delta-Y =     2.00000
```

```
------------- a2918020 T=18  H=60  Jonswap -------------
--------------------------------------------------------- Channel  1

  Raw data time series statistics
             Mean ....... =  -3.5212E-02
             Variance ... =   1.3786E-01
             Energy ..... =   1.3786E-01
Total smoothed energy ..................... =    1.37644E-01
Maximum smoothed value .................... =    1.15779E+00
First moment .............................. =    5.21791E-02
Second moment ............................. =    2.38867E-02
Hmo ....................................... =    1.484

Max density =       2.65680  at X =   .30030 Hz.      3.3300 sec.
YMAX =    3.00000   Delta-Y =      .60000

--------------------------------------------------------- Channel  2

  Raw data time series statistics
             Mean ....... =  -1.4996E-02
             Variance ... =   1.9071E-01
             Energy ..... =   1.9071E-01
Total smoothed energy ..................... =    1.90649E-01
Maximum smoothed value .................... =    1.62238E+00
First moment .............................. =    7.24980E-02
Second moment ............................. =    3.36556E-02
Hmo ....................................... =    1.747

Max density =       2.65680  at X =   .30213 Hz.      3.3099 sec.
YMAX =    3.00000   Delta-Y =      .60000

--------------------------------------------------------- Channel  3

  Raw data time series statistics
             Mean ....... =  -5.4839E-02
             Variance ... =   1.8071E-01
             Energy ..... =   1.8071E-01
Total smoothed energy ..................... =    1.80634E-01
Maximum smoothed value .................... =    1.59058E+00
First moment .............................. =    6.69613E-02
Second moment ............................. =    3.07014E-02
Hmo ....................................... =    1.700

Max density =       2.65680  at X =   .30213 Hz.      3.3099 sec.
YMAX =    3.00000   Delta-Y =      .60000

--------------------------------------------------------- Channel  4

  Raw data time series statistics
             Mean ....... =  -4.6413E-02
             Variance ... =   1.8489E-01
             Energy ..... =   1.8488E-01
Total smoothed energy ..................... =    1.84800E-01
Maximum smoothed value .................... =    1.46688E+00
First moment .............................. =    6.97763E-02
Second moment ............................. =    3.30440E-02
Hmo ....................................... =    1.720

Max density =       2.65680  at X =   .29480 Hz.      3.3921 sec.
YMAX =    3.00000   Delta-Y =      .60000

------------- a2918020 T=18  H=60  Jonswap -------------
--------------------------------------------------------- Channel  5

  Raw data time series statistics
             Mean ....... =  -3.1899E-02
             Variance ... =   1.7521E-01
             Energy ..... =   1.7521E-01
Total smoothed energy ..................... =    1.75112E-01
Maximum smoothed value .................... =    1.44419E+00
First moment .............................. =    6.75978E-02
Second moment ............................. =    3.36490E-02
Hmo ....................................... =    1.674

Max density =       2.65680  at X =   .29480 Hz.      3.3921 sec.
YMAX =    3.00000   Delta-Y =      .60000

--------------------------------------------------------- Channel  6

  Raw data time series statistics
             Mean ....... =   7.9331E-03
             Variance ... =   8.9985E-01
             Energy ..... =   8.9983E-01
Total smoothed energy ..................... =    8.98000E-01
Maximum smoothed value .................... =    8.69098E+00
First moment .............................. =    2.83155E-01
Second moment ............................. =    9.90964E-02
Hmo ....................................... =    3.791

Max density =       8.69098  at X =   .30030 Hz.      3.3300 sec.
YMAX =   10.00000   Delta-Y =     2.00000

--------------------------------------------------------- Channel  8

  Raw data time series statistics
             Mean ....... =  -2.3283E-03
             Variance ... =   8.0379E-01
             Energy ..... =   8.0376E-01
Total smoothed energy ..................... =    8.00961E-01
Maximum smoothed value .................... =    7.80625E+00
First moment .............................. =    2.54984E-01
Second moment ............................. =    9.15063E-02
Hmo ....................................... =    3.580

Max density =       7.80625  at X =   .29480 Hz.      3.3921 sec.
YMAX =   10.00000   Delta-Y =     2.00000

------------- a2916024 T=16  H=70  Jonswap -------------
--------------------------------------------------------- Channel  1

  Raw data time series statistics
             Mean ....... =  -5.4077E-02
             Variance ... =   1.7289E-01
             Energy ..... =   1.7288E-01
Total smoothed energy ..................... =    1.72594E-01
Maximum smoothed value .................... =    1.90479E+00
First moment .............................. =    6.77775E-02
Second moment ............................. =    3.17582E-02
Hmo ....................................... =    1.662

Max density =       3.22030  at X =   .33142 Hz.      3.0173 sec.
YMAX =    4.00000   Delta-Y =      .80000

--------------------------------------------------------- Channel  2

  Raw data time series statistics
             Mean ....... =  -2.8188E-02
             Variance ... =   2.2202E-01
             Energy ..... =   2.2202E-01
Total smoothed energy ..................... =    2.21905E-01
Maximum smoothed value .................... =    2.35796E+00
First moment .............................. =    8.96765E-02
Second moment ............................. =    4.49343E-02
Hmo ....................................... =    1.884

Max density =       3.22030  at X =   .33142 Hz.      3.0173 sec.
YMAX =    4.00000   Delta-Y =      .80000

--------------------------------------------------------- Channel  3

  Raw data time series statistics
             Mean ....... =  -7.0049E-02
             Variance ... =   1.9692E-01
             Energy ..... =   1.9691E-01
Total smoothed energy ..................... =    1.96715E-01
Maximum smoothed value .................... =    1.75586E+00
First moment .............................. =    8.00573E-02
Second moment ............................. =    4.19987E-02
Hmo ....................................... =    1.774

Max density =       3.22030  at X =   .33142 Hz.      3.0173 sec.
YMAX =    4.00000   Delta-Y =      .80000

--------------------------------------------------------- Channel  4

  Raw data time series statistics
             Mean ....... =  -5.9227E-02
             Variance ... =   2.0190E-01
             Energy ..... =   2.0190E-01
Total smoothed energy ..................... =    2.01717E-01
Maximum smoothed value .................... =    2.00962E+00
First moment .............................. =    8.02953E-02
Second moment ............................. =    4.07085E-02
Hmo ....................................... =    1.797

Max density =       3.22030  at X =   .33142 Hz.      3.0173 sec.
YMAX =    4.00000   Delta-Y =      .80000

------------- a2916024 T=16  H=70  Jonswap -------------
--------------------------------------------------------- Channel  5

  Raw data time series statistics
             Mean ....... =  -4.4323E-02
             Variance ... =   1.9203E-01
             Energy ..... =   1.9202E-01
Total smoothed energy ..................... =    1.91827E-01
Maximum smoothed value .................... =    1.70745E+00
First moment .............................. =    7.82463E-02
Second moment ............................. =    4.17124E-02
Hmo ....................................... =    1.752

Max density =       3.22030  at X =   .33142 Hz.      3.0173 sec.
YMAX =    4.00000   Delta-Y =      .80000

--------------------------------------------------------- Channel  6

  Raw data time series statistics
             Mean ....... =   4.1208E-02
             Variance ... =   1.1201E+00
             Energy ..... =   1.1201E+00
Total smoothed energy ..................... =    1.11394E+00
Maximum smoothed value .................... =    1.38346E+01
First moment .............................. =    3.63993E-01
Second moment ............................. =    1.33087E-01
Hmo ....................................... =    4.222

Max density =      13.83456  at X =   .33142 Hz.      3.0173 sec.
YMAX =   15.00000   Delta-Y =     3.00000

--------------------------------------------------------- Channel  8

  Raw data time series statistics
             Mean ....... =   1.9679E-02
             Variance ... =   9.3631E-01
             Energy ..... =   9.3629E-01
Total smoothed energy ..................... =    9.32162E-01
Maximum smoothed value .................... =    1.13424E+01
First moment .............................. =    3.10893E-01
Second moment ............................. =    1.18525E-01
Hmo ....................................... =    3.862

Max density =      11.34242  at X =   .33142 Hz.      3.0173 sec.
YMAX =   15.00000   Delta-Y =     3.00000
```

```
------------- a3414028 T=14  H=70  Jonswap -------------
---------------------------------------------------------- Channel  1

 Raw data time series statistics
            Mean ....... =   6.0294E-02
            Variance ... =   1.2768E-01
            Energy ..... =   1.2767E-01
Total smoothed energy .................... =    1.27407E-01
Maximum smoothed value ................... =    9.35089E-01
First moment ............................. =    5.71841E-02
Second moment ............................ =    2.91787E-02
Hmo ...................................... =    1.428

Max density =     1.91730  at X =   .39917 Hz.     2.5052 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  2

 Raw data time series statistics
            Mean ....... =   4.8839E-02
            Variance ... =   1.6090E-01
            Energy ..... =   1.6089E-01
Total smoothed energy .................... =    1.60834E-01
Maximum smoothed value ................... =    1.42161E+00
First moment ............................. =    7.50600E-02
Second moment ............................ =    4.13994E-02
Hmo ...................................... =    1.604

Max density =     1.91730  at X =   .42481 Hz.     2.3540 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  3

 Raw data time series statistics
            Mean ....... =   3.0536E-02
            Variance ... =   1.4416E-01
            Energy ..... =   1.4415E-01
Total smoothed energy .................... =    1.44037E-01
Maximum smoothed value ................... =    1.31949E+00
First moment ............................. =    6.70216E-02
Second moment ............................ =    3.74307E-02
Hmo ...................................... =    1.518

Max density =     1.91730  at X =   .42481 Hz.     2.3540 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  4

 Raw data time series statistics
            Mean ....... =   5.0167E-02
            Variance ... =   1.5187E-01
            Energy ..... =   1.5186E-01
Total smoothed energy .................... =    1.51783E-01
Maximum smoothed value ................... =    1.44062E+00
First moment ............................. =    7.06108E-02
Second moment ............................ =    3.97897E-02
Hmo ...................................... =    1.558

Max density =     1.91730  at X =   .42664 Hz.     2.3439 sec.
YMAX =    2.50000   Delta-Y =     .50000

------------- a3414028 T=14  H=70  Jonswap -------------
---------------------------------------------------------- Channel  5

 Raw data time series statistics
            Mean ....... =   6.5282E-02
            Variance ... =   1.3296E-01
            Energy ..... =   1.3296E-01
Total smoothed energy .................... =    1.32853E-01
Maximum smoothed value ................... =    8.84094E-01
First moment ............................. =    6.34542E-02
Second moment ............................ =    3.81656E-02
Hmo ...................................... =    1.458

Max density =     1.91730  at X =   .42481 Hz.     2.3540 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  6

 Raw data time series statistics
            Mean ....... =  -5.3690E-03
            Variance ... =   8.2514E-01
            Energy ..... =   8.2512E-01
Total smoothed energy .................... =    8.21212E-01
Maximum smoothed value ................... =    6.91119E+00
First moment ............................. =    3.14978E-01
Second moment ............................ =    1.33861E-01
Hmo ...................................... =    3.625

Max density =     6.91119  at X =   .42481 Hz.     2.3540 sec.
YMAX =    7.50000   Delta-Y =    1.50000

---------------------------------------------------------- Channel  8

 Raw data time series statistics
            Mean ....... =   4.1260E-02
            Variance ... =   6.9917E-01
            Energy ..... =   6.9914E-01
Total smoothed energy .................... =    6.96553E-01
Maximum smoothed value ................... =    6.19359E+00
First moment ............................. =    2.69993E-01
Second moment ............................ =    1.17662E-01
Hmo ...................................... =    3.338

Max density =     6.19359  at X =   .42481 Hz.     2.3540 sec.
YMAX =    7.50000   Delta-Y =    1.50000

------------- a3416031 T=16  H=70  Jonswap -------------
---------------------------------------------------------- Channel  1

 Raw data time series statistics
            Mean ....... =   6.1460E-03
            Variance ... =   1.3136E-01
            Energy ..... =   1.3136E-01
Total smoothed energy .................... =    1.31020E-01
Maximum smoothed value ................... =    1.00294E+00
First moment ............................. =    5.50835E-02
Second moment ............................ =    2.69051E-02
Hmo ...................................... =    1.448

Max density =     2.19000  at X =   .37537 Hz.     2.6640 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  2

 Raw data time series statistics
            Mean ....... =  -2.7359E-03
            Variance ... =   1.6943E-01
            Energy ..... =   1.6942E-01
Total smoothed energy .................... =    1.69336E-01
Maximum smoothed value ................... =    1.48291E+00
First moment ............................. =    7.37574E-02
Second moment ............................ =    3.90142E-02
Hmo ...................................... =    1.646

Max density =     2.19000  at X =   .37171 Hz.     2.6903 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  3

 Raw data time series statistics
            Mean ....... =  -2.2776E-02
            Variance ... =   1.3959E-01
            Energy ..... =   1.3959E-01
Total smoothed energy .................... =    1.39458E-01
Maximum smoothed value ................... =    9.94139E-01
First moment ............................. =    6.18006E-02
Second moment ............................ =    3.40490E-02
Hmo ...................................... =    1.494

Max density =     2.19000  at X =   .37537 Hz.     2.6640 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  4

 Raw data time series statistics
            Mean ....... =  -6.8801E-03
            Variance ... =   1.3880E-01
            Energy ..... =   1.3879E-01
Total smoothed energy .................... =    1.38666E-01
Maximum smoothed value ................... =    8.18865E-01
First moment ............................. =    6.07584E-02
Second moment ............................ =    3.37384E-02
Hmo ...................................... =    1.490

Max density =     2.19000  at X =   .37537 Hz.     2.6640 sec.
YMAX =    2.50000   Delta-Y =     .50000

------------- a3416031 T=16  H=70  Jonswap -------------
---------------------------------------------------------- Channel  5

 Raw data time series statistics
            Mean ....... =   1.2792E-02
            Variance ... =   1.4102E-01
            Energy ..... =   1.4101E-01
Total smoothed energy .................... =    1.40893E-01
Maximum smoothed value ................... =    1.14066E+00
First moment ............................. =    6.27103E-02
Second moment ............................ =    3.59485E-02
Hmo ...................................... =    1.501

Max density =     2.19000  at X =   .35523 Hz.     2.8151 sec.
YMAX =    2.50000   Delta-Y =     .50000

---------------------------------------------------------- Channel  6

 Raw data time series statistics
            Mean ....... =   2.0711E-02
            Variance ... =   9.2705E-01
            Energy ..... =   9.2703E-01
Total smoothed energy .................... =    9.21712E-01
Maximum smoothed value ................... =    8.04228E+00
First moment ............................. =    3.30265E-01
Second moment ............................ =    1.30736E-01
Hmo ...................................... =    3.840

Max density =     8.04228  at X =   .35889 Hz.     2.7864 sec.
YMAX =   10.00000   Delta-Y =    2.00000

---------------------------------------------------------- Channel  8

 Raw data time series statistics
            Mean ....... =   4.0705E-02
            Variance ... =   7.6546E-01
            Energy ..... =   7.6545E-01
Total smoothed energy .................... =    7.61784E-01
Maximum smoothed value ................... =    6.09090E+00
First moment ............................. =    2.77151E-01
Second moment ............................ =    1.14228E-01
Hmo ...................................... =    3.491

Max density =     6.09090  at X =   .35523 Hz.     2.8151 sec.
YMAX =   10.00000   Delta-Y =    2.00000
```

```
------------- a3418034 T=18  H=70  Jonswap -------------
----------------------------------------------------------- Channel  1

  Raw data time series statistics
             Mean ....... =   2.7181E-02
             Variance ... =   1.3095E-01
             Energy ..... =   1.3094E-01
Total smoothed energy .................... =    1.30603E-01
Maximum smoothed value ................... =    1.30002E+00
First moment ............................. =    5.09955E-02
Second moment ............................ =    2.37816E-02
Hmo ...................................... =    1.446

Max density =      2.45650  at X =   .32044 Hz.     3.1207 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  2

  Raw data time series statistics
             Mean ....... =   1.5136E-02
             Variance ... =   1.6878E-01
             Energy ..... =   1.6878E-01
Total smoothed energy .................... =    1.68705E-01
Maximum smoothed value ................... =    1.43009E+00
First moment ............................. =    6.85757E-02
Second moment ............................ =    3.45634E-02
Hmo ...................................... =    1.643

Max density =      2.45650  at X =   .32044 Hz.     3.1207 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  3

  Raw data time series statistics
             Mean ....... =  -2.6533E-03
             Variance ... =   1.4979E-01
             Energy ..... =   1.4978E-01
Total smoothed energy .................... =    1.49657E-01
Maximum smoothed value ................... =    1.08129E+00
First moment ............................. =    6.33674E-02
Second moment ............................ =    3.46765E-02
Hmo ...................................... =    1.547

Max density =      2.45650  at X =   .32776 Hz.     3.0510 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  4

  Raw data time series statistics
             Mean ....... =   1.2529E-02
             Variance ... =   1.5481E-01
             Energy ..... =   1.5481E-01
Total smoothed energy .................... =    1.54666E-01
Maximum smoothed value ................... =    1.20647E+00
First moment ............................. =    6.47448E-02
Second moment ............................ =    3.51966E-02
Hmo ...................................... =    1.573

Max density =      2.45650  at X =   .32776 Hz.     3.0510 sec.
YMAX =    3.00000   Delta-Y =      .60000
```

```
------------- a3418034 T=18  H=70  Jonswap -------------
----------------------------------------------------------- Channel  5

  Raw data time series statistics
             Mean ....... =   3.1561E-02
             Variance ... =   1.5199E-01
             Energy ..... =   1.5199E-01
Total smoothed energy .................... =    1.51828E-01
Maximum smoothed value ................... =    1.27421E+00
First moment ............................. =    6.49645E-02
Second moment ............................ =    3.70283E-02
Hmo ...................................... =    1.559

Max density =      2.45650  at X =   .32776 Hz.     3.0510 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  6

  Raw data time series statistics
             Mean ....... =   2.2652E-02
             Variance ... =   9.9789E-01
             Energy ..... =   9.9787E-01
Total smoothed energy .................... =    9.95158E-01
Maximum smoothed value ................... =    1.07519E+01
First moment ............................. =    3.27707E-01
Second moment ............................ =    1.20712E-01
Hmo ...................................... =    3.990

Max density =     10.75192  at X =   .32044 Hz.     3.1207 sec.
YMAX =   15.00000   Delta-Y =     3.00000

----------------------------------------------------------- Channel  8

  Raw data time series statistics
             Mean ....... =   4.2597E-02
             Variance ... =   8.5020E-01
             Energy ..... =   8.5018E-01
Total smoothed energy .................... =    8.47138E-01
Maximum smoothed value ................... =    8.91927E+00
First moment ............................. =    2.88065E-01
Second moment ............................ =    1.12502E-01
Hmo ...................................... =    3.682

Max density =      8.91927  at X =   .32776 Hz.     3.0510 sec.
YMAX =   15.00000   Delta-Y =     3.00000
```

```
------------- b3418048 T=18  H=70  Jonswap -------------
----------------------------------------------------------- Channel  1

  Raw data time series statistics
             Mean ....... =   2.0553E-01
             Variance ... =   1.5822E-01
             Energy ..... =   1.5821E-01
Total smoothed energy .................... =    1.56713E-01
Maximum smoothed value ................... =    1.44430E+00
First moment ............................. =    6.20073E-02
Second moment ............................ =    3.00307E-02
Hmo ...................................... =    1.583

Max density =      2.45650  at X =   .32593 Hz.     3.0681 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  2

  Raw data time series statistics
             Mean ....... =  -5.2369E-02
             Variance ... =   1.8668E-01
             Energy ..... =   1.8667E-01
Total smoothed energy .................... =    1.86527E-01
Maximum smoothed value ................... =    1.52037E+00
First moment ............................. =    7.55150E-02
Second moment ............................ =    3.85488E-02
Hmo ...................................... =    1.728

Max density =      2.45650  at X =   .32593 Hz.     3.0681 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  3

  Raw data time series statistics
             Mean ....... =  -6.7306E-02
             Variance ... =   1.5846E-01
             Energy ..... =   1.5846E-01
Total smoothed energy .................... =    1.58308E-01
Maximum smoothed value ................... =    1.16135E+00
First moment ............................. =    6.57434E-02
Second moment ............................ =    3.50213E-02
Hmo ...................................... =    1.592

Max density =      2.45650  at X =   .32593 Hz.     3.0681 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  4

  Raw data time series statistics
             Mean ....... =  -4.8735E-02
             Variance ... =   1.7608E-01
             Energy ..... =   1.7607E-01
Total smoothed energy .................... =    1.75955E-01
Maximum smoothed value ................... =    1.53699E+00
First moment ............................. =    7.16760E-02
Second moment ............................ =    3.74640E-02
Hmo ...................................... =    1.678

Max density =      2.45650  at X =   .32593 Hz.     3.0681 sec.
YMAX =    3.00000   Delta-Y =      .60000
```

```
------------- b3418048 T=18  H=70  Jonswap -------------
----------------------------------------------------------- Channel  5

  Raw data time series statistics
             Mean ....... =  -2.6489E-01
             Variance ... =   1.6151E-01
             Energy ..... =   1.6151E-01
Total smoothed energy .................... =    1.61330E-01
Maximum smoothed value ................... =    1.30851E+00
First moment ............................. =    6.79638E-02
Second moment ............................ =    3.84440E-02
Hmo ...................................... =    1.607

Max density =      2.45650  at X =   .32593 Hz.     3.0681 sec.
YMAX =    3.00000   Delta-Y =      .60000

----------------------------------------------------------- Channel  6

  Raw data time series statistics
             Mean ....... =   1.8206E-02
             Variance ... =   1.1238E+00
             Energy ..... =   1.1237E+00
Total smoothed energy .................... =    1.11838E+00
Maximum smoothed value ................... =    1.18491E+01
First moment ............................. =    3.66562E-01
Second moment ............................ =    1.34394E-01
Hmo ...................................... =    4.230

Max density =     11.84912  at X =   .31678 Hz.     3.1568 sec.
YMAX =   15.00000   Delta-Y =     3.00000

----------------------------------------------------------- Channel  8

  Raw data time series statistics
             Mean ....... =  -2.7227E-02
             Variance ... =   8.2767E-01
             Energy ..... =   8.2765E-01
Total smoothed energy .................... =    8.23944E-01
Maximum smoothed value ................... =    8.54373E+00
First moment ............................. =    2.76624E-01
Second moment ............................ =    1.06311E-01
Hmo ...................................... =    3.631

Max density =      8.54373  at X =   .32044 Hz.     3.1207 sec.
YMAX =   15.00000   Delta-Y =     3.00000
```

```
------------- b3416049 T=16  H=70  Jonswap -------------
---------------------------------------------------------- Channel  1

 Raw data time series statistics
            Mean ....... =   2.1247E-01
            Variance ... =   1.4442E-01
            Energy ..... =   1.4441E-01
Total smoothed energy .................... =    1.43852E-01
Maximum smoothed value ................... =    1.19421E+00
First moment ............................. =    6.16746E-02
Second moment ............................ =    3.20948E-02
Hmo ...................................... =    1.517

Max density =      2.19000  at X =   .36072 Hz.     2.7722 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  2

 Raw data time series statistics
            Mean ....... =  -4.5625E-02
            Variance ... =   1.6786E-01
            Energy ..... =   1.6786E-01
Total smoothed energy .................... =    1.67753E-01
Maximum smoothed value ................... =    1.61787E+00
First moment ............................. =    7.25665E-02
Second moment ............................ =    3.88034E-02
Hmo ...................................... =    1.638

Max density =      2.19000  at X =   .36072 Hz.     2.7722 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  3

 Raw data time series statistics
            Mean ....... =  -5.7856E-02
            Variance ... =   1.5173E-01
            Energy ..... =   1.5173E-01
Total smoothed energy .................... =    1.51636E-01
Maximum smoothed value ................... =    1.38055E+00
First moment ............................. =    6.63166E-02
Second moment ............................ =    3.61630E-02
Hmo ...................................... =    1.558

Max density =      2.19000  at X =   .36072 Hz.     2.7722 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  4

 Raw data time series statistics
            Mean ....... =  -4.1765E-02
            Variance ... =   1.5321E-01
            Energy ..... =   1.5321E-01
Total smoothed energy .................... =    1.53113E-01
Maximum smoothed value ................... =    1.21973E+00
First moment ............................. =    6.58448E-02
Second moment ............................ =    3.52055E-02
Hmo ...................................... =    1.565

Max density =      2.19000  at X =   .34790 Hz.     2.8744 sec.
YMAX =    2.50000   Delta-Y =      .50000
```

```
------------- b3416049 T=16  H=70  Jonswap -------------
---------------------------------------------------------- Channel  5

 Raw data time series statistics
            Mean ....... =  -2.5418E-01
            Variance ... =   1.5640E-01
            Energy ..... =   1.5639E-01
Total smoothed energy .................... =    1.56304E-01
Maximum smoothed value ................... =    1.54161E+00
First moment ............................. =    6.86051E-02
Second moment ............................ =    3.85542E-02
Hmo ...................................... =    1.581

Max density =      2.19000  at X =   .36072 Hz.     2.7722 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  6

 Raw data time series statistics
            Mean ....... =   2.5835E-02
            Variance ... =   9.8077E-01
            Energy ..... =   9.8076E-01
Total smoothed energy .................... =    9.74035E-01
Maximum smoothed value ................... =    9.72835E+00
First moment ............................. =    3.37674E-01
Second moment ............................ =    1.32646E-01
Hmo ...................................... =    3.948

Max density =      9.72835  at X =   .36072 Hz.     2.7722 sec.
YMAX =   15.00000   Delta-Y =     3.00000

---------------------------------------------------------- Channel  8

 Raw data time series statistics
            Mean ....... =  -3.0522E-02
            Variance ... =   7.1071E-01
            Energy ..... =   7.1069E-01
Total smoothed energy .................... =    7.07966E-01
Maximum smoothed value ................... =    6.86901E+00
First moment ............................. =    2.51008E-01
Second moment ............................ =    1.02349E-01
Hmo ...................................... =    3.366

Max density =      6.86901  at X =   .34790 Hz.     2.8744 sec.
YMAX =   15.00000   Delta-Y =     3.00000
```

```
------------- b3414050 T=14  H=70  Jonswap -------------
---------------------------------------------------------- Channel  1

 Raw data time series statistics
            Mean ....... =   2.0021E-01
            Variance ... =   1.3008E-01
            Energy ..... =   1.3008E-01
Total smoothed energy .................... =    1.29750E-01
Maximum smoothed value ................... =    8.86817E-01
First moment ............................. =    5.97956E-02
Second moment ............................ =    3.19512E-02
Hmo ...................................... =    1.441

Max density =      1.91730  at X =   .41748 Hz.     2.3953 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  2

 Raw data time series statistics
            Mean ....... =  -4.8481E-02
            Variance ... =   1.5224E-01
            Energy ..... =   1.5223E-01
Total smoothed energy .................... =    1.52113E-01
Maximum smoothed value ................... =    1.23702E+00
First moment ............................. =    7.21210E-02
Second moment ............................ =    4.12223E-02
Hmo ...................................... =    1.560

Max density =      1.91730  at X =   .41748 Hz.     2.3953 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  3

 Raw data time series statistics
            Mean ....... =  -5.9653E-02
            Variance ... =   1.5239E-01
            Energy ..... =   1.5239E-01
Total smoothed energy .................... =    1.52296E-01
Maximum smoothed value ................... =    1.37097E+00
First moment ............................. =    7.10510E-02
Second moment ............................ =    3.97694E-02
Hmo ...................................... =    1.561

Max density =      1.91730  at X =   .41565 Hz.     2.4058 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  4

 Raw data time series statistics
            Mean ....... =  -4.5383E-02
            Variance ... =   1.4768E-01
            Energy ..... =   1.4767E-01
Total smoothed energy .................... =    1.47560E-01
Maximum smoothed value ................... =    1.34083E+00
First moment ............................. =    6.85086E-02
Second moment ............................ =    3.84071E-02
Hmo ...................................... =    1.537

Max density =      1.91730  at X =   .43396 Hz.     2.3043 sec.
YMAX =    2.50000   Delta-Y =      .50000
```

```
------------- b3414050 T=14  H=70  Jonswap -------------
---------------------------------------------------------- Channel  5

 Raw data time series statistics
            Mean ....... =  -2.5780E-01
            Variance ... =   1.4462E-01
            Energy ..... =   1.4461E-01
Total smoothed energy .................... =    1.44492E-01
Maximum smoothed value ................... =    9.99468E-01
First moment ............................. =    6.89720E-02
Second moment ............................ =    4.13065E-02
Hmo ...................................... =    1.520

Max density =      1.91730  at X =   .43396 Hz.     2.3043 sec.
YMAX =    2.50000   Delta-Y =      .50000

---------------------------------------------------------- Channel  6

 Raw data time series statistics
            Mean ....... =   6.9439E-03
            Variance ... =   8.2059E-01
            Energy ..... =   8.2057E-01
Total smoothed energy .................... =    8.15979E-01
Maximum smoothed value ................... =    6.47513E+00
First moment ............................. =    3.08706E-01
Second moment ............................ =    1.32551E-01
Hmo ...................................... =    3.613

Max density =      6.47513  at X =   .41748 Hz.     2.3953 sec.
YMAX =    7.50000   Delta-Y =     1.50000

---------------------------------------------------------- Channel  8

 Raw data time series statistics
            Mean ....... =   1.5431E-02
            Variance ... =   6.1160E-01
            Energy ..... =   6.1158E-01
Total smoothed energy .................... =    6.08109E-01
Maximum smoothed value ................... =    4.80730E+00
First moment ............................. =    2.35306E-01
Second moment ............................ =    1.03457E-01
Hmo ...................................... =    3.119

Max density =      4.80730  at X =   .43396 Hz.     2.3043 sec.
YMAX =    7.50000   Delta-Y =     1.50000
```

```
------------- b3412051 T=12  H=70  Jonswap -------------
---------------------------------------------------------- Channel  1

 Raw data time series statistics
            Mean ....... =   1.5893E-01
            Variance ... =   1.0915E-01
            Energy ..... =   1.0914E-01
Total smoothed energy .................... =    1.08576E-01
Maximum smoothed value ................... =    1.12943E+00
First moment ............................. =    5.29863E-02
Second moment ............................ =    2.97180E-02
Hmo ...................................... =    1.318

Max density =     1.64250   at X =   .46143 Hz.     2.1672 sec.
YMAX =    2.00000   Delta-Y =     .40000

---------------------------------------------------------- Channel  2

 Raw data time series statistics
            Mean ....... =  -2.7680E-02
            Variance ... =   1.3580E-01
            Energy ..... =   1.3580E-01
Total smoothed energy .................... =    1.35698E-01
Maximum smoothed value ................... =    1.20915E+00
First moment ............................. =    6.81604E-02
Second moment ............................ =    4.05195E-02
Hmo ...................................... =    1.473

Max density =     1.64250   at X =   .46143 Hz.     2.1672 sec.
YMAX =    2.00000   Delta-Y =     .40000

---------------------------------------------------------- Channel  3

 Raw data time series statistics
            Mean ....... =  -4.0444E-02
            Variance ... =   1.3919E-01
            Energy ..... =   1.3919E-01
Total smoothed energy .................... =    1.39088E-01
Maximum smoothed value ................... =    1.24606E+00
First moment ............................. =    6.79234E-02
Second moment ............................ =    3.90660E-02
Hmo ...................................... =    1.492

Max density =     1.64250   at X =   .46143 Hz.     2.1672 sec.
YMAX =    2.00000   Delta-Y =     .40000

---------------------------------------------------------- Channel  4

 Raw data time series statistics
            Mean ....... =  -2.5518E-02
            Variance ... =   1.4425E-01
            Energy ..... =   1.4424E-01
Total smoothed energy .................... =    1.44147E-01
Maximum smoothed value ................... =    1.41104E+00
First moment ............................. =    7.07092E-02
Second moment ............................ =    4.10354E-02
Hmo ...................................... =    1.519

Max density =     1.64250   at X =   .46143 Hz.     2.1672 sec.
YMAX =    2.00000   Delta-Y =     .40000
```

```
------------- b3412051 T=12  H=70  Jonswap -------------
---------------------------------------------------------- Channel  5

 Raw data time series statistics
            Mean ....... =  -2.4835E-01
            Variance ... =   1.3628E-01
            Energy ..... =   1.3628E-01
Total smoothed energy .................... =    1.36187E-01
Maximum smoothed value ................... =    1.17473E+00
First moment ............................. =    6.99095E-02
Second moment ............................ =    4.47272E-02
Hmo ...................................... =    1.476

Max density =     1.64250   at X =   .46143 Hz.     2.1672 sec.
YMAX =    2.00000   Delta-Y =     .40000

---------------------------------------------------------- Channel  6

 Raw data time series statistics
            Mean ....... =  -2.1020E-04
            Variance ... =   6.6926E-01
            Energy ..... =   6.6924E-01
Total smoothed energy .................... =    6.66826E-01
Maximum smoothed value ................... =    6.30702E+00
First moment ............................. =    2.70848E-01
Second moment ............................ =    1.23484E-01
Hmo ...................................... =    3.266

Max density =     6.30702   at X =   .46143 Hz.     2.1672 sec.
YMAX =    7.50000   Delta-Y =    1.50000

---------------------------------------------------------- Channel  8

 Raw data time series statistics
            Mean ....... =   1.1803E-02
            Variance ... =   5.3226E-01
            Energy ..... =   5.3224E-01
Total smoothed energy .................... =    5.28785E-01
Maximum smoothed value ................... =    5.32451E+00
First moment ............................. =    2.18736E-01
Second moment ............................ =    1.00852E-01
Hmo ...................................... =    2.909

Max density =     5.32451   at X =   .46143 Hz.     2.1672 sec.
YMAX =    7.50000   Delta-Y =    1.50000
```

```
------------ b3420052 T=20  H=70  Jonswap -------------
---------------------------------------------------------- Channel  1

 Raw data time series statistics
            Mean ....... =   1.5273E-01
            Variance ... =   1.2198E-01
            Energy ..... =   1.2198E-01
Total smoothed energy .................... =    1.17841E-01
Maximum smoothed value ................... =    1.07107E+00
First moment ............................. =    4.30985E-02
Second moment ............................ =    2.03168E-02
Hmo ...................................... =    1.373

Max density =     2.73650   at X =   .29297 Hz.     3.4133 sec.
YMAX =    3.00000   Delta-Y =     .60000

---------------------------------------------------------- Channel  2

 Raw data time series statistics
            Mean ....... =  -3.2632E-02
            Variance ... =   1.7425E-01
            Energy ..... =   1.7424E-01
Total smoothed energy .................... =    1.74020E-01
Maximum smoothed value ................... =    1.86172E+00
First moment ............................. =    6.48862E-02
Second moment ............................ =    3.08517E-02
Hmo ...................................... =    1.669

Max density =     2.73650   at X =   .29297 Hz.     3.4133 sec.
YMAX =    3.00000   Delta-Y =     .60000

---------------------------------------------------------- Channel  3

 Raw data time series statistics
            Mean ....... =  -4.7685E-02
            Variance ... =   1.4846E-01
            Energy ..... =   1.4845E-01
Total smoothed energy .................... =    1.48203E-01
Maximum smoothed value ................... =    1.34556E+00
First moment ............................. =    5.73288E-02
Second moment ............................ =    2.94567E-02
Hmo ...................................... =    1.540

Max density =     2.73650   at X =   .29297 Hz.     3.4133 sec.
YMAX =    3.00000   Delta-Y =     .60000

---------------------------------------------------------- Channel  4

 Raw data time series statistics
            Mean ....... =  -2.9994E-02
            Variance ... =   1.6328E-01
            Energy ..... =   1.6327E-01
Total smoothed energy .................... =    1.63071E-01
Maximum smoothed value ................... =    1.64381E+00
First moment ............................. =    6.18955E-02
Second moment ............................ =    3.12974E-02
Hmo ...................................... =    1.615

Max density =     2.73650   at X =   .29297 Hz.     3.4133 sec.
YMAX =    3.00000   Delta-Y =     .60000
```

```
----------- b3420052 T=20  H=70  Jonswap -------------
---------------------------------------------------------- Channel  5

 Raw data time series statistics
            Mean ....... =  -2.5792E-01
            Variance ... =   1.4215E-01
            Energy ..... =   1.4214E-01
Total smoothed energy .................... =    1.42005E-01
Maximum smoothed value ................... =    1.12780E+00
First moment ............................. =    5.56765E-02
Second moment ............................ =    3.03905E-02
Hmo ...................................... =    1.507

Max density =     2.73650   at X =   .29297 Hz.     3.4133 sec.
YMAX =    3.00000   Delta-Y =     .60000

---------------------------------------------------------- Channel  6

 Raw data time series statistics
            Mean ....... =   2.2534E-02
            Variance ... =   1.0601E+00
            Energy ..... =   1.0601E+00
Total smoothed energy .................... =    1.05530E+00
Maximum smoothed value ................... =    1.16949E+01
First moment ............................. =    3.16725E-01
Second moment ............................ =    1.09806E-01
Hmo ...................................... =    4.109

Max density =    11.69492   at X =   .29297 Hz.     3.4133 sec.
YMAX =   15.00000   Delta-Y =    3.00000

---------------------------------------------------------- Channel  8

 Raw data time series statistics
            Mean ....... =  -1.2480E-02
            Variance ... =   7.8822E-01
            Energy ..... =   7.8820E-01
Total smoothed energy .................... =    7.84545E-01
Maximum smoothed value ................... =    8.74762E+00
First moment ............................. =    2.44994E-01
Second moment ............................ =    8.98887E-02
Hmo ...................................... =    3.543

Max density =     8.74762   at X =   .29297 Hz.     3.4133 sec.
YMAX =   15.00000   Delta-Y =    3.00000
```

```
------------- b3414063 T=14  H=60  Jonswap -------------
-------------------------------------------------------------  Channel  1

  Raw data time series statistics
             Mean ....... =    1.0108E-01
             Variance ... =    9.4562E-02
             Energy ..... =    9.4558E-02
Total smoothed energy .................... =    9.31843E-02
Maximum smoothed value ................... =    6.95094E-01
First moment ............................. =    4.29168E-02
Second moment ............................ =    2.31992E-02
Hmo ...................................... =    1.221

Max density =      1.40950  at X =   .40467 Hz.     2.4712 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  2

  Raw data time series statistics
             Mean ....... =   -1.0534E-01
             Variance ... =    1.2575E-01
             Energy ..... =    1.2575E-01
Total smoothed energy .................... =    1.25654E-01
Maximum smoothed value ................... =    1.05217E+00
First moment ............................. =    5.91261E-02
Second moment ............................ =    3.30217E-02
Hmo ...................................... =    1.418

Max density =      1.40950  at X =   .40467 Hz.     2.4712 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  3

  Raw data time series statistics
             Mean ....... =   -1.1724E-01
             Variance ... =    1.2138E-01
             Energy ..... =    1.2137E-01
Total smoothed energy .................... =    1.21280E-01
Maximum smoothed value ................... =    1.04719E+00
First moment ............................. =    5.67808E-02
Second moment ............................ =    3.21695E-02
Hmo ...................................... =    1.393

Max density =      1.40950  at X =   .40467 Hz.     2.4712 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  4

  Raw data time series statistics
             Mean ....... =   -1.0292E-01
             Variance ... =    1.1397E-01
             Energy ..... =    1.1397E-01
Total smoothed energy .................... =    1.13873E-01
Maximum smoothed value ................... =    7.58103E-01
First moment ............................. =    5.37363E-02
Second moment ............................ =    3.14083E-02
Hmo ...................................... =    1.350

Max density =      1.40950  at X =   .41748 Hz.     2.3953 sec.
YMAX =     2.00000   Delta-Y =      .40000
```

```
------------- b3414063 T=14  H=60  Jonswap -------------
-------------------------------------------------------------  Channel  5

  Raw data time series statistics
             Mean ....... =   -3.2237E-01
             Variance ... =    1.1384E-01
             Energy ..... =    1.1384E-01
Total smoothed energy .................... =    1.13725E-01
Maximum smoothed value ................... =    7.56411E-01
First moment ............................. =    5.42539E-02
Second moment ............................ =    3.28485E-02
Hmo ...................................... =    1.349

Max density =      1.40950  at X =   .40467 Hz.     2.4712 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  6

  Raw data time series statistics
             Mean ....... =    4.0185E-02
             Variance ... =    6.7676E-01
             Energy ..... =    6.7675E-01
Total smoothed energy .................... =    6.72830E-01
Maximum smoothed value ................... =    5.93586E+00
First moment ............................. =    2.59907E-01
Second moment ............................ =    1.12050E-01
Hmo ...................................... =    3.281

Max density =      5.93586  at X =   .40467 Hz.     2.4712 sec.
YMAX =     7.50000   Delta-Y =     1.50000

-------------------------------------------------------------  Channel  8

  Raw data time series statistics
             Mean ....... =    2.5802E-02
             Variance ... =    4.9291E-01
             Energy ..... =    4.9290E-01
Total smoothed energy .................... =    4.88408E-01
Maximum smoothed value ................... =    3.79410E+00
First moment ............................. =    1.90723E-01
Second moment ............................ =    8.42197E-02
Hmo ...................................... =    2.795

Max density =      3.79410  at X =   .40467 Hz.     2.4712 sec.
YMAX =     7.50000   Delta-Y =     1.50000
```

```
------------- b3416064 T=16  H=60  Jonswap -------------
-------------------------------------------------------------  Channel  1

  Raw data time series statistics
             Mean ....... =    7.8713E-02
             Variance ... =    9.1088E-02
             Energy ..... =    9.1085E-02
Total smoothed energy .................... =    8.99622E-02
Maximum smoothed value ................... =    7.32196E-01
First moment ............................. =    3.81204E-02
Second moment ............................ =    1.91084E-02
Hmo ...................................... =    1.200

Max density =      1.61000  at X =   .37903 Hz.     2.6383 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  2

  Raw data time series statistics
             Mean ....... =   -8.7127E-02
             Variance ... =    1.4180E-01
             Energy ..... =    1.4180E-01
Total smoothed energy .................... =    1.41659E-01
Maximum smoothed value ................... =    1.29839E+00
First moment ............................. =    6.18161E-02
Second moment ............................ =    3.28287E-02
Hmo ...................................... =    1.506

Max density =      1.61000  at X =   .36805 Hz.     2.7171 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  3

  Raw data time series statistics
             Mean ....... =   -9.8918E-02
             Variance ... =    1.3287E-01
             Energy ..... =    1.3287E-01
Total smoothed energy .................... =    1.32729E-01
Maximum smoothed value ................... =    1.11979E+00
First moment ............................. =    5.79963E-02
Second moment ............................ =    3.07037E-02
Hmo ...................................... =    1.457

Max density =      1.61000  at X =   .37903 Hz.     2.6383 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  4

  Raw data time series statistics
             Mean ....... =   -8.5839E-02
             Variance ... =    1.3112E-01
             Energy ..... =    1.3112E-01
Total smoothed energy .................... =    1.30965E-01
Maximum smoothed value ................... =    9.67082E-01
First moment ............................. =    5.65412E-02
Second moment ............................ =    3.01104E-02
Hmo ...................................... =    1.448

Max density =      1.61000  at X =   .34973 Hz.     2.8593 sec.
YMAX =     2.00000   Delta-Y =      .40000
```

```
------------- b3416064 T=16  H=60  Jonswap -------------
-------------------------------------------------------------  Channel  5

  Raw data time series statistics
             Mean ....... =   -3.1182E-01
             Variance ... =    1.3427E-01
             Energy ..... =    1.3426E-01
Total smoothed energy .................... =    1.34168E-01
Maximum smoothed value ................... =    1.18948E+00
First moment ............................. =    5.95581E-02
Second moment ............................ =    3.39688E-02
Hmo ...................................... =    1.465

Max density =      1.61000  at X =   .36255 Hz.     2.7582 sec.
YMAX =     2.00000   Delta-Y =      .40000

-------------------------------------------------------------  Channel  6

  Raw data time series statistics
             Mean ....... =    3.6745E-02
             Variance ... =    8.0394E-01
             Energy ..... =    8.0392E-01
Total smoothed energy .................... =    7.99149E-01
Maximum smoothed value ................... =    7.57297E+00
First moment ............................. =    2.86416E-01
Second moment ............................ =    1.13158E-01
Hmo ...................................... =    3.576

Max density =      7.57297  at X =   .36988 Hz.     2.7036 sec.
YMAX =    10.00000   Delta-Y =     2.00000

-------------------------------------------------------------  Channel  8

  Raw data time series statistics
             Mean ....... =    3.8042E-02
             Variance ... =    6.0462E-01
             Energy ..... =    6.0460E-01
Total smoothed energy .................... =    6.02655E-01
Maximum smoothed value ................... =    5.40855E+00
First moment ............................. =    2.19881E-01
Second moment ............................ =    8.95741E-02
Hmo ...................................... =    3.105

Max density =      5.40855  at X =   .36255 Hz.     2.7582 sec.
YMAX =    10.00000   Delta-Y =     2.00000
```

```
------------- b3412065 T=12  H=60  Jonswap -------------
-------------------------------------------------------------- Channel  1

  Raw data time series statistics
             Mean ....... =   6.1847E-02
             Variance ... =   8.1261E-02
             Energy ..... =   8.1258E-02
Total smoothed energy .................... =    7.95091E-02
Maximum smoothed value ................... =    6.29903E-01
First moment ............................. =    3.88268E-02
Second moment ............................ =    2.15099E-02
Hmo ...................................... =    1.128

Max density =      1.20750  at X =   .46875 Hz.     2.1333 sec.
YMAX =    1.50000   Delta-Y =      .30000

-------------------------------------------------------------- Channel  2

  Raw data time series statistics
             Mean ....... =  -8.5990E-02
             Variance ... =   1.2022E-01
             Energy ..... =   1.2022E-01
Total smoothed energy .................... =    1.20119E-01
Maximum smoothed value ................... =    8.52053E-01
First moment ............................. =    6.17594E-02
Second moment ............................ =    3.70765E-02
Hmo ...................................... =    1.386

Max density =      1.20750  at X =   .45594 Hz.     2.1933 sec.
YMAX =    1.50000   Delta-Y =      .30000

-------------------------------------------------------------- Channel  3

  Raw data time series statistics
             Mean ....... =  -9.9580E-02
             Variance ... =   1.1751E-01
             Energy ..... =   1.1750E-01
Total smoothed energy .................... =    1.17416E-01
Maximum smoothed value ................... =    9.47581E-01
First moment ............................. =    5.79501E-02
Second moment ............................ =    3.31964E-02
Hmo ...................................... =    1.371

Max density =      1.20750  at X =   .45594 Hz.     2.1933 sec.
YMAX =    1.50000   Delta-Y =      .30000

-------------------------------------------------------------- Channel  4

  Raw data time series statistics
             Mean ....... =  -8.4586E-02
             Variance ... =   1.1928E-01
             Energy ..... =   1.1927E-01
Total smoothed energy .................... =    1.19177E-01
Maximum smoothed value ................... =    1.07708E+00
First moment ............................. =    5.93003E-02
Second moment ............................ =    3.44822E-02
Hmo ...................................... =    1.381

Max density =      1.20750  at X =   .45594 Hz.     2.1933 sec.
YMAX =    1.50000   Delta-Y =      .30000
```

```
------------- b3412065 T=12  H=60  Jonswap -------------
-------------------------------------------------------------- Channel  5

  Raw data time series statistics
             Mean ....... =  -3.1477E-01
             Variance ... =   1.0746E-01
             Energy ..... =   1.0746E-01
Total smoothed energy .................... =    1.07394E-01
Maximum smoothed value ................... =    8.53929E-01
First moment ............................. =    5.58159E-02
Second moment ............................ =    3.61035E-02
Hmo ...................................... =    1.311

Max density =      1.20750  at X =   .45594 Hz.     2.1933 sec.
YMAX =    1.50000   Delta-Y =      .30000

-------------------------------------------------------------- Channel  6

  Raw data time series statistics
             Mean ....... =   1.0189E-02
             Variance ... =   5.6515E-01
             Energy ..... =   5.6514E-01
Total smoothed energy .................... =    5.60991E-01
Maximum smoothed value ................... =    4.66954E+00
First moment ............................. =    2.34313E-01
Second moment ............................ =    1.09209E-01
Hmo ...................................... =    2.996

Max density =      4.66954  at X =   .45594 Hz.     2.1933 sec.
YMAX =    5.00000   Delta-Y =     1.00000

-------------------------------------------------------------- Channel  8

  Raw data time series statistics
             Mean ....... =   4.9145E-02
             Variance ... =   4.5211E-01
             Energy ..... =   4.5210E-01
Total smoothed energy .................... =    4.50154E-01
Maximum smoothed value ................... =    4.27547E+00
First moment ............................. =    1.90301E-01
Second moment ............................ =    8.92143E-02
Hmo ...................................... =    2.684

Max density =      4.27547  at X =   .45594 Hz.     2.1933 sec.
YMAX =    5.00000   Delta-Y =     1.00000
```